HELIOS PLUS

2287A DATA ACQUISITION FRONT END

System Manual

Volume 1 (Sections 1-4)

P/N 865295 (2 Volume Set)
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PREFACE

How to Use This Manual

The Fluke Helios Plus Data Acquisition and Control Front End is a member of an exceptional family of Front Ends and Data Loggers. This Front End offers a full line of field-proven data acquisition hardware. It is both easy to configure and to integrate into a mainframe or personal computer-based measurement system.

This manual has been designed with a variety of readers in mind. The job you will be doing with the Front End will partly determine how you can get the most benefit from this manual.

Volume 1 contains Sections 1 through 4. Volume 2 contains Sections 5 through 9. An index covering both volumes is found at the end of each volume.

System Designers

To design and assemble the components of a measurement/data acquisition system you need in-depth information about the capabilities, specifications, and available operations of the proposed equipment. As a system designer, you are not as interested in keystroke-level operations as in the operational characteristics of the unit. If you need this kind of information, begin in Section 2, Specifications. Section 2 gives the specifications of the Front End and all available options. If you need to know more about how the Front End operates, read the introductory parts of Section 4, Using the Commands. You might also look up selected topics of interest in the index.

Applications Engineers

This manual was written mainly for applications engineers who will be installing, connecting, and programming the Helios Plus Front End. The major sections are tab-divided for quick reference when you're in a hurry. Also, the sections are divided into conveniently sized tasks.

When you're just beginning to use this manual, you'll probably make the best headway by first scanning it to familiarize yourself with its organization. Then, depending on your specific task, you might branch to the section on installation. If someone else has already installed the system and you need to begin programming the Front End, then Section 4 will get you going quickly. After that, you'll probably only need Section 5 as a reference to the commands.

Technicians

Persons installing, operating, troubleshooting, or changing the configuration of the measurement system may need just about any piece of information in this manual. If you are to be the system technician, you will probably need to consult the table of contents and the index to locate what you need. For schematics or other servicing information, order Fluke Part Number 873794, Helios Plus Front End Service Manual from your local Fluke Service Center (see Appendix D).

Carefully follow all the installation instructions when you are first setting up the system. If you feel you have a service problem, be sure to call your Fluke service representative for assistance.

Purchasing Agents

If you make purchasing decisions, you have probably already seen the specifications for the Helios Plus Front End. This manual can still help in your task. Section 2 is entirely devoted to the specifications of the mainframe and all the available options.

However, specifications alone may not provide enough information to evaluate the instrument. You may be interested in some less tangible factors, like ease-of-use. Reading the introductory parts of Section 3, Installation, can help you get a feel for the task of setting up the system you have in mind. Similarly, glancing over Section 4, Using the Commands, should indicate how communications are established between the computer and the measurement system.

Incoming Inspectors/QA

If you wish to put Helios Plus through its paces, Section 2A provides everything you need. Performance testing procedures for the mainframe and all option assemblies are included here.

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GETTING STARTED - INTRODUCTION

The Fluke Helios Plus Data Acquisition Front End is a data acquisition and control subsystem that can be used with any kind of personal or mainframe computer. The Front End combines a full range of measurement capabilities with easy programmability. It includes:

- An RS-232-C and an RS-422 standard serial interface port for communication with a host computer.
- A microcomputer with ROM and RAM to provide local intelligence.
- Six option slots that accept any of a range of measurement and control modules, supporting a variety of both analog and digital inputs and outputs. Expansion chassis can be added to accommodate a maximum of 1000 channels in the system.

The Data Acquisition Front End is a smart intermediary between a computer and a real world measurement application. Through a standard computer interface, the Front End gathers data about physical quantities and generates control or stimulus signals.

The Front End is a medium speed, highly accurate measurement and control system. It can be adapted to a very broad spectrum of applications, with a capacity ranging from a single channel in a minimal configuration to 1000 channels in a fully expanded system.

A microcomputer in the Front End executes commands received from the host computer, drives the measurement and control hardware, and sends appropriate responses back to the host. The command set is a collection of high level instructions, presented in a readable and easy-to-grasp format.

Channel definition commands select ranges and sensor types. From then on, automatic signal conditioning and data conversion take place for sensors as common as thermocouples, RTDs and strain gauges, or as unique as a user-defined sensor type. Thus, the Front End responds to a measurement request command by returning a value in appropriate units of measurement. Conversely, a channel set command, which assigns a value to a control output, is translated into an electrical signal.

Each of four different channel groups can be scanned over time intervals specified directly by Helios Plus. If the host computer is allocated to a higher priority task, data buffers can be used for temporary storage of monitored inputs or outputs.

Helios Plus provides for extensive alarm testing and communications. Two high alarm limits and two low alarm limits can be established for each channel. Alarm outputs can be coupled to a regular status output channel or to special audible and/or visual alarm indicators. If the host computer does not communicate with Helios Plus for a specified period, alarm data can be logged on a printer connected directly to Helios Plus. Further, Helios Plus can initiate communication with the host computer if an alarm condition has occurred.

Information from monitored channels can also be logged on a printer (or crt terminal) connected directly to Helios Plus.

Math functions are available to deal with minimum or maximum values, to show the average or total of values measured, or to treat values as inputs to polynomial or square root functions.

Functions

Helios Plus can be fitted with a High Performance A/D Converter (-161) or a Fast A/D Converter (-165). Combinations of a/d converters are also allowed. Note that speed and accuracy specifications may differ for the same function, depending on the a/d converter in use. These specification differences are mentioned in Section 2 of this manual.

Table 1-1 lists the functions supported by each a/d converter.

Table 1-1. A/D Converter Functions

	-161 High Performance A/D	-165 Fast A/D
ANALOG INPUTS		
DCV	Yes	Yes
ACV	Yes	
Temperature		
Thermocouples	Yes	Yes
RTDs		
Config. A	Yes	
Config. B	Yes	Yes
Config. C		Yes
Thermistors	Yes	
Resistance		
Config. A	Yes	
Config. B	Yes	Yes
Config. C		Yes
DCA	Yes	Yes
Strain	Yes	Yes

The following functions require one or more option assemblies, but do not require an a/d converter; Helios Plus can be equipped for these functions irrespective of the a/d converter configuration.

- Frequency Measurement
- Totalizing Measurement
- DC Voltage Output
- DC Current Output
- Digital Inputs
- Status Inputs
- Digital Outputs

Additional Capabilities (Fast A/D Converter)

The Fast A/D Converter can operate in either Continuous Scan Mode or Burst Scan Mode. Both modes provide the additional capability of measuring a signal referenced to the a/d converter common (single-ended) or to a signal level on another channel (differential).

In other areas, the two scan modes differ, as follows:

- Continuous Scan Mode

  This is the default state for the Fast A/D Converter. Measurement channel readings are continuously made available, allowing the host computer to obtain up to 70 readings per second.

- Burst Scan Mode

  This mode buffers scanned channel measurement data at 1000 measurements per second. Burst mode must be initiated with a specific command and can be stopped when either a specially-defined trigger event occurs or a specific stop command is sent. Special commands allow for set up of Burst Scan Mode parameters and retrieval of recorded data.

THE MEASUREMENT SYSTEM

The Helios Plus measurement system has been designed with a modular architecture that allows great flexibility in hardware configuration and placement. At the heart of the system is the Front End mainframe.

The Mainframe

The mainframe is a chassis packaged in a vinyl-clad housing with carrying handles and feet. The feet can be removed for mounting the instrument into a standard 19" instrument rack.

The Front End mainframe is supplied with a computer interface module that includes a 16-bit microprocessor. Nonvolatile RAM holds information about channel sensors, and EPROMs contain a command interpreter and tables for converting the output of commonly-used sensors into engineering units.

Six horizontal slots in the rear of the mainframe can accept any of a complete set of measurement and output options. An extender chassis is available if more slots are needed, or if the system architecture requires the options to be remotely located.

Extender Chassis

The 2281A Extender Chassis is a passive unit that acts as an extension of the mainframe. Like the mainframe, this extender also contains six horizontal slots in the rear panel for accepting options, and it can be used as a bench instrument or mounted in a standard 19" instrument rack.

The Front End and its associated options all use a distributed system design that allows great flexibility in hardware placement. All of the measurement and output options communicate with the computer interface module over a high-speed serial communications link. This design permits any option assembly that can be installed in the mainframe to be installed in an Extender Chassis located up to 1,000 meters away. All measurements are digitized at the remote location and transmitted back to the Front End over the serial link. This approach greatly reduces wiring costs and assures accurate measurements in electrically noisy environments.

Fig 1-1 illustrates the distributed system concept.

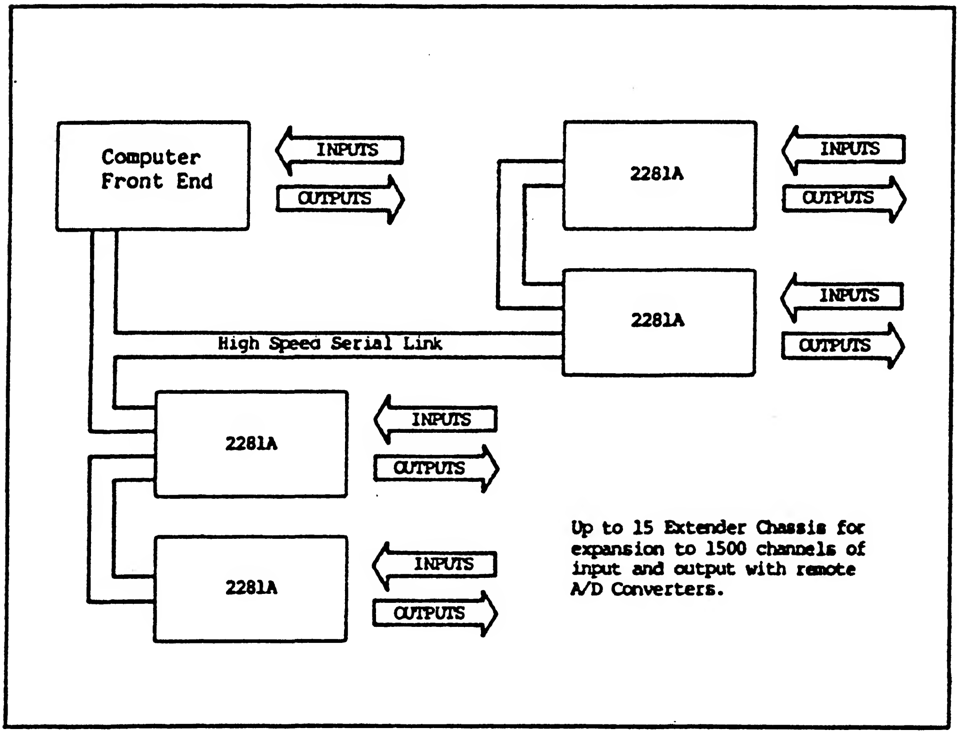


Figure 1-1. Distributed System Concept

Option Assemblies

All connections between the Front End and the process to be monitored or controlled are made through plug-in option assemblies. The use of option assemblies allows for a wide range of configurations. The option assemblies slip into position easily from the Front End's access panel. Installation and use of each assembly is documented in Section 3B of this manual. The options are categorized as follows:

OPTION CARDS

Option cards are circuit cards that can be installed in either the Front End or the 2281A Extender Chassis. These are the devices that link the measurement environment to the Front End. The option cards are described below and demonstrated in possible configurations in Table 1-2.

- High Performance A/D Converter (-161)

  High Performance A/D converter with 17 bits of resolution. Up to 10 per system, each measuring up to 100 channels. Compared with the -165 Fast A/D Converter, this converter provides higher accuracy at a slower speed. It is also better for taking measurements in the presence of high voltage and/or high noise.

- Thermocouple/DC Volts Scanner (-162)

  A 20-channel, 3-pole reed multiplexer for voltage, current and thermocouple measurements. Used with a -161 High Performance A/D Converter.

- RTD/Resistance Scanner (-163)

  A 20-channel reed multiplexer with on-board excitation for resistance and RTD measurements. Used with a -161 High Performance A/D Converter.

- o Transducer Excitation Module (-164)

  Isolated transducer excitation module with current and voltage sources for strain and resistance measurements. Used in conjunction with either a 3-pole scanner card or the -165 Fast A/D Converter.

- o Fast A/D Converter (-165)

  High speed a/d converter, with continuous and burst scanning modes. Up to 20 per system, each measuring up to 20 differential channels, 40 single-ended channels, or a mixture of differential and single-ended channels. When compared with the -161 High Performance A/D Converter, this converter provides somewhat lower accuracy at a much higher speed.

- o Counter/Totalizer (-167)

  A 6-channel, isolated event counting and frequency measurement card.

- o Digital I/O Assembly (-168)

  A 20-bit, isolated digital I/O card for parallel or single-bit I/O.

- o Analog Output (-170)

  A 4-channel, isolated current/voltage analog output card (D/A converter).

Table 1-2. Option Configurations

FUNCTIONS	HARDWARE REQUIRED -161 A/D	-165 A/D	Non A/D
DC Volts	-162/-175	/-175	
	-162/-176	/-176	
	-162/-160		
Thermocouple	-162/-175	/-175	
RTD	-162/-175	/-175	
	/-176	/-176	
	-164/-174	-164/-174	
Thermistor	-163/-177		
DC Current	-162/-171	/-175	
		/-176	
Strain	-162/-175	/-175	
	/-176	/-176	
	-164/-174	-164/-174	
AC Volts	-162/-160		
Frequency			-167
Totalizing			-167
Analog Output			-170
Binary/BCD Inputs			-168/-169
Status Input			-168/-169
Status Output			-168/-179

("/-" before number shows options attaching directly)

CONNECTOR OPTIONS

Connector options are modules that plug onto another option card. They allow for wiring connections and routing to the measurement environment. The available option connectors are listed below and demonstrated in possible configurations in Table 1-2.

- AC Voltage Input Connector (-160)
- Digital/Status Input Connector (-168)
- Status Output Connector (-169)
- Current Input Connector (-171)
- Transducer Excitation Connector (-174)
- Isothermal Input Connector (-175)
- Voltage Input Connector (-176)

Accessories

Several option assemblies apply specifically to use of the 2281A Extender Chassis with the Front End. Installation instructions for these options are provided in Section 3 of this manual. Complete documentation can be found in the 2281A Instruction Manual.

- Extender Cable (2281A-402)

  When used with the 2281A-403 cable connector, this assembly provides the serial link interface between two Extender Chassis.

- Extender Cable Connector (2281A-403)

  This is a set of male/female 15-pin, D-type connectors. A housing provides strain relief for cable connections and stand-off bolts for securing the cable connector to the mainframe connector.

- Power Supply (2281A-431)

  This assembly provides a regulated 20V dc source for option devices when the extender chassis placement (distance) and configuration (number of devices) exceed the power capabilities of the Front End.

The following accessories are available to aid in installing either the Front End or the 2281A Extender Chassis:

- Y1702, Y1703, Y1705 Null Modem Cables

  For connecting the Front End to the host computer, these cables are 2 meters, 4 meters, and 25 centimeters long respectively. Both ends have DB 25S (Socket) connectors.

- Y1707, Y1708 RS-232 Interface Cables

  These RS-232 cables are 2 meters and 10 meters in length respectively. One end has a DB 25S (Socket) and the other other a DB 25S (Plug) connector.

- Y2044 Rack Slide Kit

  This accessory facilitates servicing the Front End (or 2281A) while it is installed in a standard 19-inch electronic equipment rack. The unit is secured in the equipment rack, yet may be pulled out along the slide for servicing and reconfiguring of serial link devices.

- o Y2045 Rack Mount Kit

  This kit facilitates placing a Front End or 2281A into a standard 19-inch electronic equipment rack.

- o Y2047 Serial Link Multiconnect

  This accessory is used in 2281A placements to support star configurations.

GETTING STARTED - SETUP

The remainder of this section describes the steps to follow in setting up the Data Acquisition Front End when it is being installed for the first time.

Unpacking

To unpack the Front End, first examine the shipping container for any obvious damage. If no damage is apparent, open the container and remove enough packing material to expose the instrument and remove it.

Verify that each pca (printed circuit assembly) is firmly seated in the chassis. If shipping and handling have loosened any pca, fully insert these pca's before proceeding. Refer to Section 3 or to the appropriate section of the Front End Service Manual for detailed installation instructions if required.

CAUTION

Do not energize the Front End until directed to do so later in this section. Any pca loosened in shipment must be fully inserted at this time. If additional pca's are to be installed, refer to the instructions presented in Section 3B of this manual.

Along with the Front End, the shipping container holds an accessory box. Check that this box contains the line power cord and any accessories (such as cables) that were ordered.

Connecting to Your Computer or Terminal

A set of switches on the Computer Interface Module configure the Front End for host computer communications characteristics and for the incoming line power setting. Access to these switches requires removal of the Computer Interface Module from the Front End chassis.

CAUTION

Incorrect voltage selection may damage the Computer Interface Module and void your warranty. If the voltage is not set for the correct incoming power, the unit will fail to operate and may be severely damaged.

It may be possible to configure your host computer to match the factory settings of the Front End switches, and eliminate the need to remove the Computer Interface Module at this time. The factory settings of these switches correspond to these characteristics:

LINE VOLTAGE	90-132 or 180-264V ac
LINE FREQUENCY	50 or 60 Hz
COMMUNICATIONS TYPE	RS-232-C
TRANSMISSION MODE	Full Duplex
BAUD RATE	9600
PARITY	NONE
NUMBER OF DATA BITS	8
NUMBER OF STOP BITS	1
XON/XOFF	Enabled

Non-Volatile Memory Battery Charging

The Computer Interface Assembly uses rechargeable batteries to maintain its non-volatile memory.

NOTE

Programs saved on a newly-received Helios Plus may not be maintained in non-volatile memory. Any Helios Plus shipped with the Computer Interface Assembly already installed comes with the batteries connected. If such a Helios Plus has not been powered up for some time, these batteries may be at a charge state insufficient to maintain memory. Therefore, it is important to leave a newly-received Helios Plus powered up for 24 hours to allow for adequate charging.

If the Computer Interface Assembly is shipped separately, as with a module exchange, the batteries are disconnected and must be connected as shown in Figure 1-2. In this case, since there has been no drain on the batteries during transit and storage times, the charge should be sufficient to maintain non-volatile memory.

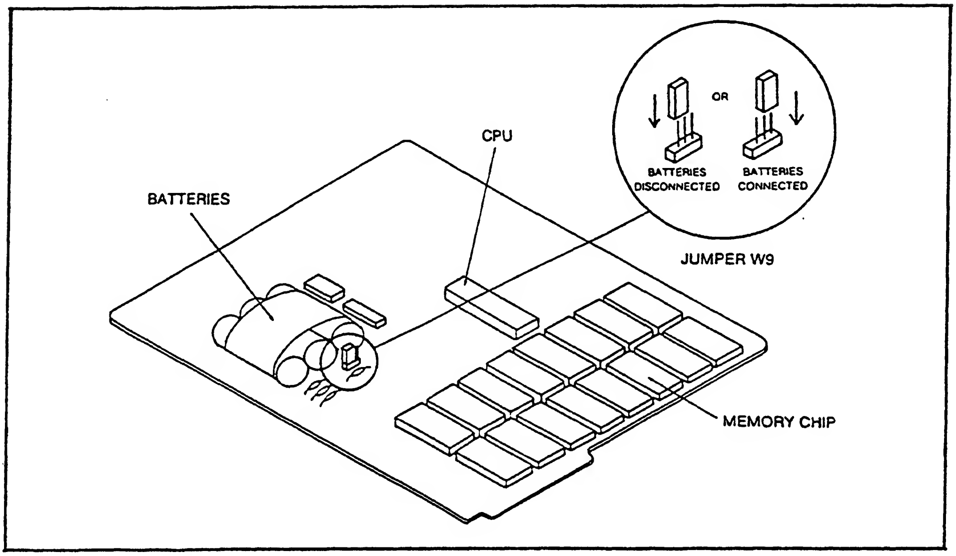


Figure 1-2. Battery Power Jumper

Cabling to the Host Computer

A cable must connect the controlling computer (or terminal) and the Front End to permit communication between the two instruments. The Front End supports two different communications standards: RS-232-C DTE (Data Terminal Equipment), and RS-422. The RS-232-C standard is the more popular of the two, and is supported to some degree by nearly all computer equipment.

Different computers and terminals support RS-232-C communications in different ways. See Appendix 9a for details on how to connect some common computers, or consult your particular computer documentation to determine cabling requirements.

If you are using RS-422 communications, or RS-232 with modems, refer to Section 3A.

COMMUNICATIONS FORMAT

Once your computer is cabled properly to the Front End, data is transferred one bit at a time over the Transmit Data and Receive Data lines. The character format and speed (baud rate) of the data transfer can vary greatly among systems. See Appendix 9b for a detailed description of serial data conventions. All computer equipment that supports RS-232 communications provides some means to select these parameters.

Though many different character formats and speeds can be successfully used, it is very important that the computer or terminal and the Front End are set to exactly the same character format and baud rate. If they are not, communications between the units will not succeed. Fluke recommends that the Front End factory default settings described earlier in this section be used to check out the operation of the system. Consult Appendix 9a or your computer documentation to set your computer to this default configuration. If for some reason your terminal or computer cannot accommodate this configuration, refer to section 3 to reconfigure the Front End to match your computer's capability.

Communicating with the Front End

The Front End does nothing until it is asked by the host computer. For this reason, it is sometimes called a "command/response" instrument. Once a request for information has been made, the Front End performs all the measurement and output functions necessary, converts inputs to engineering units (such as degrees or PSI), sends the results to the host computer, and then returns to the idle state.

Now that the Front End is properly configured and connected to your computer or terminal, you are ready to request and retrieve information from the instrument.

The Front End has been designed with a multitude of users and applications in mind, so the instrument supports two different modes of communication: Terminal Mode and Computer Mode.

Terminal Mode

In Terminal Mode, the Front end assumes that it is connected directly to a terminal and that a keyboard is communicating directly to it. To make communications easier in this situation, the Front End displays a prompt **HCLI>** on the terminal to indicate it is ready to accept a command.

As commands are received, all characters are echoed back to the the terminal so you can see what you are typing. In addition, some line editing is provided by the key which sends the ASCII <DEL> character. If a mistake is caught before <RETURN> is pressed, this key removes the last character typed.

When <RETURN> is pressed, the Front End executes the requested command. If there are any errors in the command an error message in plain English appears on the terminal display.

Terminal Mode is useful for system checkout and program development.

Computer Mode

In this mode, the Front End assumes that commands are issued from a computer program. In Computer Mode, the Front End sends a single-character prompt (!) followed by <CR><LF>. The Front End does not echo commands to the computer, and returns error information as a series of numbers because a program can decode number strings more easily than English.

Turning On the Front End

1. When the communications parameters have been set and the host computer has been connected to the Front End, apply power to the host computer or terminal. If you are using a computer, load system software.

2. Power up the Front End. Wait ten seconds for the Front End to complete its initialization routines.

3. Press the <RETURN> key (marked on the IBM PC), or whatever key is used to generate the ASCII sequence <CR>. The Front End responds by sending the prompt associated with the mode it is operating in (**!** for Computer Mode, **HCLI>** for Terminal Mode).

4. The appearance of either prompt indicates that the Front End is communicating bi-directionally with the host computer or terminal. Other responses may indicate a problem, either with the host, the Front End, or with the communications link. Recheck your work before continuing. If failure continues and your work seems to be in order, see Section 7, Maintenance.

NOTE

Remember that a Helios Plus shipped with the Computer Interface Module installed may not have a sufficient battery charge to maintain non-volatile memory for programs you create. If in doubt, leave the Helios Plus powered up for 24 hours to ensure an adequate charge.

WHERE TO GO FROM HERE

This section has presented a general procedure for setting up the Data Acquisition Front End and a computer or terminal as its host. More specific information on setting up the mainframe, options, and the Extender Chassis can be found in Section 3. Appendix 9a offers guidelines for setting up many popular computers, and includes a short installation verification program.

CONTENTS

MAINFRAME SPECIFICATIONS

Channel Capacity
- Mainframe .... 120 Differential, or 240 Single-Ended (-165), or 120 Digital
- System .... 1000 maximum

Memory .... Nonvolatile, with 15 day typical, 10 day minimum battery backup

Scanning Speed (analog inputs)

Dependent on system configuration and programming

Maximum System Scanning Speed in Channels per Second

-161 High Performance A/D Converter

-161 Converters in System	Direct Voltage Readings
1	16
2	30
3	42
4	50

-165 Fast A/D Converter

-165 Converters in System	Direct Voltage Readings Continuous	Burst
1	70	1000
2	70	2000
3	70	3000
4	70	4000

Power
AC .... 90-132V, 180-264V, 47-440 Hz
Dissipation .... <40W

Temperature
Operating .... 0 to 65°C
Storage .... -40 to 70°C

Humidity (non-condensing)
0 to 25°C .... <95%
25 to 40°C .... <75%
40 to 50°C .... <45%

Weight .... 8.5 kg (19 lbs)
Without options

Dimensions .... Height Width Depth
23.8 cm x 43.9 cm x 35.9 cm
9.35" x 17.30" x 14.13"

Altitude
Operating .... 3050m (10,000 feet)
Non-operating .... 12,200m (40,000 feet)

Shock and Vibration .... Meets MIL-T-28800C Class 5,
Style F Standard

Interface Specifications

Type .... Asynchronous, either RS-232-C or RS-422

Connector .... 25-pin male; pinout depends on S1 setting: RS-232 or RS-422

25-Pin Host Connector Pinout (S1 in RS-232-C Position)

PIN NUMBER	SIGNAL
(1)	Shield
(2)	Transmitted Data
(3)	Received Data
(4)	Request to Send
(5)	Clear to Send
(6)	Data Set Ready
(7)	Signal Ground
(8)	Received Line Signal Detector
(12)	Secondary Received Line Signal Detector
(20)	Data Terminal Ready
(22)	Ring Indicator

Required RS-232-C Signals .... Transmit Data, Receive Data, Signal Ground. All other lines are passively asserted true. Instrument will operate if these other lines are left disconnected.

RS-232 Modem Control .... Full duplex

25-Pin Connector Pinout (S1 in RS-422 Position)

PIN NUMBER	SIGNAL
(1)	Shield
(7)	Common
(9)	Transmit +
(10)	Transmit -
(14)	Receive +
(15)	Receive -

NOTE

RS-232-C signals are present on their associated pins even when S1 is set for RS-422 operation, but they are not used when configured for RS-422.

Baud Rate	Switch-selectable: 110, 300, 600, 1200, 2400, 4800, 9600, 19200
ASCII format	7 or 8 bit, 1 or 2 stop bits. Switch-selectable
Parity	Odd, even, or none. Switch-selectable
Multi-drop capability	Available via RS-422. Ten mainframes can be addressed by a host through a single RS-422 port. Address is switch-selectable.

Alarm Annunciator Terminal Strip

TERMINAL NUMBER	FUNCTION
8	Connect to normal closed contact of the alarm acknowledgement push button.
7	Connect to normally open contact of the alarm acknowledgement push button.
6	Connect to common contact of the alarm acknowledgement push button.
5	no connection
2, 4	Normally open contacts for visual alarm light (max 120V ac, 0.6A; 30V dc, 1.0A)
1, 3	Normally open contacts for audible alarm. (max 120V ac, 0.6A; 30V dc, 1.0A)

Printer Port Connector - 25 pin

PIN NUMBER	SIGNAL
1	Shield
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground

OPTION SPECIFICATIONS

-160 AC Voltage Input Connector Specifications

Channels	10 AC, 10 DC
Terminals	40 (2 per channel)
AC Voltage	
Range	5V to 250V rms
Resolution	0.1V ac
Maximum Input	250V rms between two terminals
Frequency Range	45 Hz to 450 Hz
Accuracy	See System Accuracy Specifications
Conversion Method	1/2 wave, average responding, calibrated to indicate the rms value of a sine wave.
DC Voltage	
Ranges and Accuracy	Determined by option -162.
Maximum Input	250V dc between any two terminals
Maximum Common Mode Voltage	250V dc or 250V ac rms between terminals or between a terminal and ground.
Compatibility	Attaches to -162 Thermocouple/DC Volts Scanner, which is used with -161 High Performance A/D Converter.
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%

Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-161 High Performance A/D Converter Specifications

Dynamic Range (internal)	±131,071 counts at 50 Hz ±109,226 counts at 60 Hz
Common Mode Rejection .... (with 100 ohm imbalance)	170 dB at 50 Hz ±0.1% 170 dB at 60 Hz ±0.1% 160 dB at dc
Normal Mode Rejection	60 dB at 50 Hz ±0.1% or 60 Hz ±0.1%
Isolation	250V dc or ac rms between -161 and any other module.
Measurement Method	Dual slope, integrating over 1 line cycle
Zero Stability	Automatic zero
Ranges, Resolution, Accuracy ...	Determined by Scanner (see -162 and -163 and application. See Accuracy sections: Temperature Measurement Using Thermocouples Temperature Measurement Using RTDs DC Voltage Measurement AC Voltage Measurement DC Current Measurement Resistance Measurement Strain Measurement
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-162 Thermocouple/DC Volts Scanner Specifications

Channels	20
Poles per Channel	3 (HI, LO, SHIELD)
Input Impedance	
64 mV and 512 mV Ranges	>200 megohm in parallel with 6800 pF
8V and 64V Ranges	10 megohm
Voltage Offset (max)	1 uV

Ranges and Displayed Resolution	60 Hertz	50 Hertz
64 mV Range	0.6 uV	0.5 uV
512 mV Range	5.0 uV	4.2 uV
8V Range	73 uV	61 uV
64V Range	0.6 mV	0.5 mV

Accuracy	Determined by application. See Accuracy sections: Temperature Measurement Using Thermocouples Using RTDs DC Voltage Measurement AC Voltage Measurement DC Current Measurement Resistance Measurement Strain Measurement
Zero Stability	Automatic Zero
Input Isolation	250V dc or ac rms between any two channels or any channel and ground
Overload without Damage	250V dc or 250V ac rms
Common Mode Voltage (max)	250V dc or ac rms between any 2 terminals or a terminal and ground
Common Mode Rejection (with 100 ohm imbalance)	170 dB at 50 Hz ±0.1% 170 dB at 60 Hz ±0.1% 160 dB at dc
Normal Mode Rejection	60 dB at 50 Hz ±0.1% or 60 Hz ±0.1%

Compatibility	Used with -162 Thermocouple/DC Volts Scanner or -164 Transducer Excitation Module (Configuration B).
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

Open Thermocouple Detection

Open Input .... Resistance greater than 10,000 ohms and shunt capacitance less than 0.1 uF.

9.99999E37 (overload) is returned. If SEND ERROR is sent, error 16 (OPEN TC) is returned.

Normal Input .... Resistance less than 1000 ohms, or shunt capacitance greater than 0.1 uF.

NOTE

For resistances between 1000 and 10,000 ohms, open thermocouple detection is indeterminate. Usually, a thermocouple with resistance in this range soon becomes an open input. During scanning, testing occurs with each thermocouple reading.

-163 RTD/Resistance Scanner Specifications

Channels	20
Poles per Channel	4 (HI EXCITATION, HI, LO, LO EXCITATION)
Common Return Poles	2 (LO COM for channels 0-9, LO COM for channels 10-19)
Measurement Modes (3)	4-Wire (4W) (no reed resistances in measurement path). 3-Wire Accurate (3WA) (no reed resistances in measurement path. Channels in a decade share a common return). 3-Wire Isolated (3WCM) (one reed resistance in measurement path).
Measurement Mode Selection	2 jumpers select scanner measurement mode
Current Sources	2 (1 mA, 32 uA)
Resistance Ranges, Resolution, and Excitation	
Range	256 ohm
Internal Resolution	2.4, 2.0 milliohm (60, 50 Hz.)
Excitation	1 mA
Range	2048 ohm
Internal Resolution	19, 16 milliohm (60, 50 Hz.)
Excitation	1 mA
Range	64 kilohm
Internal Resolution	0.6, 0.5 ohm (60, 50 Hz.)
Excitation	32 uA
Accuracy	Determined by application. See Accuracy sections: Temperature Measurement Using RTDs Resistance Measurement
Zero Stability	Automatic zero

Input Channel Isolation	
4-Wire (4W)	250V dc or ac rms between any two channels
3-Wire Accurate (3WA)	250V dc or ac rms between decades of channels
3-Wire Isolated (3WCM)	250V dc or ac rms between any two channels
Overload without Damage	30V dc or 24V ac rms between any two terminals of a channel
Common Mode Isolation	250V dc or ac rms between scanners, 250V dc or ac rms between decades of channels, 250V dc or ac rms between channels within a decade for 4-Wire (4W) and 3-Wire isolated (3WCM) measurement modes, 30V dc or 24V ac rms between any terminals in the same decade except between LO COM's for the 3-Wire Accurate (3WA) measurement mode
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-164 Transducer Excitation Module Specifications

Outputs	5 constant current sources 1 constant voltage source
Channels of Excitation	20, selectable in groups of 4 for either voltage or current outputs
Common Mode Voltage	No user-applied common mode voltage allowed. All sensors must be isolated.
4-Wire Resistance Measurements ..	5 constant current sources. Each source excites up to 4 transducers.
3-Wire Resistance and Strain Gage Measurements	Any combination of 1/4, 1/2, and/or Full Bridge strain gages or 3-wire RTDs with voltage excitation and user-supplied bridge completion resistors.
Current Excitation	
Excitation Current	1.0 mA
Accuracy	
Initial Setting	0.005%
Temperature 15 to 35°C	0.015%
Time since calibration ..	90 days
Temperature 15 to 35°C	0.030%
Time since calibration ..	1 year
Temperature -20 to 70°C ...	0.050%
Time since calibration ..	1 year
Temperature Coefficient (<15 or >35°C)	10 ppm per °C
Maximum Compliance Voltage ..	0.6V

Voltage Excitation	
Excitation Voltage	switch selectable to 2.0V dc or 4.0V dc
2 Volt Accuracy	
Initial Setting	0.0025%
Temperature 15 to 35°C	0.03%
Time since calibration ..	90 days
Temperature 15 to 35°C	0.04%
Time since calibration ..	1 year
Temperature -20 to 70°C ...	0.05%
Time since calibration ..	1 year
4 Volt Accuracy	
Initial Setting	0.0035%
Temperature 15 to 35°C	0.015%
Time since calibration ..	90 days
Temperature 15 to 35°C	0.030%
Time since calibration ..	1 year
Temperature -20 to 70°C ...	0.05%
Time since calibration ..	1 year
Temperature Coefficient (<15 or >35°C)	7 ppm per °C
Maximum Current	250 mA
Accuracy	Determined by application. See the Accuracy Specifications section.
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-165 Fast A/D Converter Specifications

Operating temperature range
System .... 0 to +65°C
A/D .... -20 to +70°C

Storage temperature range ... -55 to +75°C

Humidity specifications...... < 90% up to 30°C
< 75% up to 40°C
< 45% up to 50°C
< 40% up to 70°C

Channels .... 20 differential, or
40 single-ended, or
mixture of differential
and single-ended

Input Impedance
Power ON .... 100 Megohm in parallel with 0.001 uF for voltages between -12V and +12V.

1 kilohm for voltages > +12V or < -12V.

Power OFF .... 1 kilohm

Ranges and Displayed Resolution

RANGE	RESOLUTION
64 mV	2 uV
512 mV	16 uV
8V	250 uV
10.5V	350 uV

Accuracy

Determined by application. See Accuracy section.

Maximum Voltages

INPUT COMMON to EARTH GROUND (chassis ground)	170V peak
INPUT COMMON to EXTERNAL TRIGGER COMMON	170V peak
EARTH GROUND to TRIGGER COMMON	50V peak

Overload Protection (Analog Inputs)

1. Normal reading range includes +/- 10.5V around COMMON (shield terminals of connector). (The sum of normal mode voltage and common mode voltage ranging from -10.5V to +10.5V.)

2. An overload of up to 50V rms on a single channel has no effect on other channels and causes no damage.

3. Overloads between 50 and 240V rms on a single channel may blow out the fusible protection resistor on the affected channel but will not damage other channels.

4. Overvoltage inputs are normally internally clamped to approximately +/- 12.5 volts through a 1000-ohm input protection resistor. If several inputs exceed this value, and the resulting current into the protection circuitry exceeds approximately 120 milliamperes, the input protection circuitry will clamp all a/d inputs at approximately 0.5 volts until the overload is removed. If this occurs, measurements for all channels will be tagged as overrange readings.

Open Thermocouple Detection

Any input with resistance greater than 3000 ohms (and with shunt capacitance of less than 0.01 uF) is detected as an open input. An overload reading of 9.99999E37 is then returned. In response to a SEND ERROR command, error 16 OPEN TC is returned.

Any input with resistance less than 1000 ohms is treated as a good input.

For resistances between 1000 and 3000 ohms and shunt capacitances greater than 0.01 uF, open thermocouple detection is indeterminate. Usually, these conditions soon result in open inputs.

During scanning, each thermocouple is tested at intervals of less than 5 seconds.

DC Common Mode Rejection

Measurement conditions: 100-ohm unbalance, common mode voltage < 10.5 volts maximum between LOW and COMMON.

64 mV Range .... > 105 dB
512 mV Range .... > 90 dB
8V Range .... > 75 dB
10.5V Range .... > 70 dB

AC Common Mode Rejection

Measurement conditions: 120 dB rejection of ac common mode between LOW and COMMON, 1000-ohm unbalance.

160 dB rejection of ac common mode between COMMON and EARTH.

Normal Mode Rejection

OPERATING MODE	NOISE REJECTION
Burst Scan Mode (1000 readings/second)	none
Continuous Scan Mode (70 readings/second)	40 dB @ 50/60 Hz ±0.1%

External Trigger (used for Burst Scanning)

Trigger input, maximum common mode voltage to EARTH 50V

Trigger true level ..... < 2V

Trigger false level .... > 3V

Input impedance .... approximately 47 kilohms pulled up to +5 Volts

Minimum length trigger pulse 1 ms

Maximum input without damage ±50V

Trigger output .... Collector driver with 30 kilohm pullup to 5V, active low

Maximum external pullup voltage 24V

Maximum sink current .... 2 mA @ 1V, non-inductive

Maximum Reading Rates

Continuous Mode .... 70 readings/second (DVIN)

Channels are read in blocks of 10, with each block requiring 1/7 second reading time regardless of the number of channels used. The rates shown assume a full 10 channels in each block, with channel numbers beginning with 0 and ending with 9. If fewer channels are used, the reading rate changes. For example, if the five channels 0 through 4 are used in each of 7 blocks, 35 readings are made in one second.

Continuous Mode .... 35 readings/second (TC)

For TC measurements, an additional 1/7 second processing time is required for each block of ten. Using the example mentioned for DVIN (channels 0 through 4, 7 blocks), 17.5 readings are made and processed in one second.

Burst Mode .... 1000 readings/second
(plus 1 ms processing time between scans)

Power Consumption 3.0W

-167 Counter/Totalizer Specifications

Channels	6
Functions	Event counting and frequency measurement selectable by channel pairs
Timebase	
Frequency	10 MHz
Accuracy	±0.01%
Input Signals	
Types	TTL, CMOS, contacts, and analog waveforms
Minimum Pulse Width	1.25 microseconds
Minimum Signal Amplitude	175 mV rms 0.5V p-p sine wave 0.35V p-p square wave
Maximum Signal Amplitude	± 15V dc or ac peak
Adjustments	Signal threshold, deadband, and contact debounce
Frequency Measurement	
Minimum Frequency	2 Hz
Maximum Frequency	400 kHz
Accuracy	Timebase accuracy ± 1 digit
Totalizing Measurement	
Maximum Counts	8,388,607
Counting Rate	dc to 400 kHz
Isolation	30V dc or ac rms between any terminal and ground. No isolation between channels.
Power Consumption	4.0 watts maximum

```
Temperature
    Operating ................ -20 to 70 degrees Celsius
    Storage .................. -55 to 75 degrees Celsius
Relative Humidity (without condensation)
    Below 25 degrees Celsius ....... <= 95%
    25 to 40 degrees Celsius ....... <= 75%
    40 to 50 degrees Celsius ....... <= 45%
    50 to 70 degrees Celsius ....... <= 40%

Altitude
    Non-Operating ............ 40,000 feet
    Operating ................ 10,000 feet
Shock and Vibration .......... Meets MIL-T-28800C, Class 5
                               Standards
```

-168 Digital I/O Specifications

Isolation	30V dc or ac rms between any terminal and ground.
Input Line	Pulled up to +5V through a 47K ohm resistor.
Input Handshake Line Circuit	Pulled up to +5V through a 47K ohm resistor.
Inputs	
Channels	20 single bit, or one 5 BCD digit word, or one 17-bit binary word
Type	Low Power Schottky TTL
Maximum Input Voltage	6V
Outputs	
Channels	20 single bit
Type	Open-collector, diode clamped, NPN transistors
Output Drive	100 mA with 1V drop
Maximum Voltage on Output	30V dc
Power Consumption	1.5 watts maximum
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-169 Status Output Connector Specifications

Outputs	20*
Terminals	2 per channel
Compatibility	Connects to Digital I/O (option 168)
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

* Maximum of 40 usable as alarm outputs with 2287A.

-170 Analog Output Specifications

Channels	4
Terminals	5 per channel
Accuracy	±0.1% of range
Time since calibration	90 days
Operating Temperature	15 to 35°
Accuracy	±0.2% of range
Time since calibration	1 year
Operating Temperature	15 to 35°C
Accuracy	±0.4% of range
Time since calibration	1 year
Operating Temperature	-20 to 70°C
Noise	< 0.02% of range in a 10 kHz bandwidth
Voltage Outputs	
Ranges	-5 to +5V, 0 to +10V
Resolution	2.5 mV/count
Maximum Current	5 mA
Capacitive Load	10,000 pF maximum
Output Protection	short-circuit protected
Current Output	
Range	4 to 20 mA
Resolution	4 uA
Maximum Compliance Voltage	10V
Maximum External Voltage	±24V
Isolation	30V dc or ac rms between any terminal and ground. No isolation between channels. Current outputs share a common return.
Power Consumption	4.1 watts maximum

```
Temperature
    Operating .................... -20 to 70°
    Storage ...................... -55 to 75°
Relative Humidity (without condensation)
    Below 25° .................. <= 95%
    25 to 40° .................. <= 75%
    40 to 50° .................. <= 45%
    50 to 70° .................. <= 40%
Altitude
    Non-Operating ............... 40,000 feet
    Operating ................... 10,000 feet
Shock and Vibration ............. Meets MIL-T-28800C,
                                  Class 5 Standards
```

-171 Current Input Connector Specifications

Channels	20
Terminals	2 per channel
Shunt Resistor	8 ohms $\pm$0.02 ohm
Measurement Range	64 mA
Overload without Damage	250 mA
Common Mode Voltage	250V dc or ac rms between any two channels or between a channel and ground.
Accuracy	0.25% Input $\pm$4 uA
Time since A/D calibration ..	90 days
Resolution	1 uA
Compatibility	Attaches to -162 Thermocouple/DC Volts Scanner, which is used with -161 High Performance A/D Converter
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-174 Transducer Excitation Connector Specifications

Channels	20
Terminals	5 per channel
Programming	5 jumpers select voltage or current excitation on 5 groups of 4 channels.
Compatibility	Attaches to Transducer Excitation Module (option 164)
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-175 Isothermal Input Connector Specifications

Channels .... 20 differential
40 single-ended (-165 A/D)

Terminals .... 60 (HI, LO, SHIELD per channel)

Maximum Voltage Rating (with -162 scanner)
.... 250V dc or ac rms from any terminal to any other terminal or ground.

Maximum Voltage Rating (with -165 A/D Converter)

Measurement Inputs
.... ±170V peak, any terminal to ground

±10.5V HI to COMMON (SHIELD) and/or LO to COMMON (SHIELD) for rated accuracy

±50V peak HI or LO to COMMON (SHIELD) without damage, ±50V on one channel causes no added error on other channels

±50 to 170V HI and/or LO to COMMON (SHIELD) opens fusible resistor, causing no added error on other channels.

All COMMON (SHIELD) terminals are connected together on the -165 and must be at the same voltage.

External Trigger (uses channels 0, 20 when defined)	
....	±50V peak from EXTERNAL TRIGGER COMMON to EARTH.
	±50V peak from EXTERNAL TRIGGER COMMON to MEASUREMENT COMMON.
Compatibility	Attaches directly to -165 Fast A/D Converter, or to -162 Thermocouple/DC Volts Scanner if -161 High Performance A/D Converter used.
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-176 Voltage Input Connector Specifications

Channels	20 differential 40 single-ended (-165 A/D)
Terminals	60 (HI, LO, SHIELD per channel)
Maximum Voltage Rating (with -162 scanner)	250V dc or ac rms from any terminal to any other terminal or ground.
Maximum Voltage Rating (with -165 A/D Converter) Measurement Inputs	±170V peak, any terminal to ground ±10.5V HI to COMMON (SHIELD) and/or LO to COMMON (SHIELD) for rated accuracy ±50V peak HI or LO to COMMON (SHIELD) without damage, ±50V on one channel causes no added error on other channels ±50 to 170V HI and/or LO to COMMON (SHIELD) opens fusible resistor, causing no added error on other channels. All COMMON (SHIELD) terminals are connected together on the -165 and must be at the same voltage.

External Trigger (uses channels 0, 20 when defined)	
....	±50V peak from EXTERNAL TRIGGER COMMON to EARTH.
	±50V peak from EXTERNAL TRIGGER COMMON to MEASUREMENT COMMON.
Compatibility	Attaches directly to -165 Fast A/D Converter, or to -162 Thermocouple/DC Volts Scanner if -161 High Performance A/D Converter used.
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-177 RTD/Resistance Input Connector Specifications

Channels 20
Terminals 100
(HI EXC, HI, LO, LO EXC, and LO COM per Channel)
Maximum Wire Size 14AWG
Maximum Voltage Rating and
Mating RTD/Resistance Scanner Mode
163 Measurement Mode 4-wire (4W)
Ratings .... 250V dc or ac rms between two channels or a channel and ground; 30V or 24V ac rms between channel terminals

163 Measurement Mode .... 3-wire Accurate (3WA)
Ratings .... 250V dc or ac rms between channels in different decades or between channels in a decade and ground; 30V dc or 24V ac rms between terminals within a decade except between LO COMs. (LO COMs of channels in a decade are connected internally.)

163 Measurement Mode .... 3-Wire Isolated (3WCM)
Ratings .... Same as for 4-Wire
Compatibility .... Attaches to RTD/Resistance Scanner (Option 163)

Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°
Relative Humidity (without condensation)	
Below 25°	<= 95%
25 to 40°	<= 75%
40 to 50°	<= 45%
50 to 70°	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets Mil-T-28800C, Class 5 standards

-179 Digital/Status Input Connector Specifications

Channels	20 single bit, or one 5 BCD digit word, or one 17-bit binary word
Terminals	72
Maximum Input Voltage	6V dc
Isolation	30V dc or ac rms between any terminal and ground.
Compatibility	Attaches to Digital I/O (option 168)
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

ACCURACY SPECIFICATIONS

Temperature Measurement Using Thermocouples (-161 A/D Converter)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-175 Isothermal Input Connector

Accuracy In $\pm{}^{o}C$

Thermocouple Type (Sensor Temperature Range) Sensor Temperature (°C)	Time Since A/D Calibration (Operating Temperature in °C)		
	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
J NBS (-200 to 760°C)			
-100 to -25	0.45	0.5	0.8
-25 to +760	0.35	0.4	0.7
J DIN (-200 to 900°C)			
-100 to -25	0.5	0.56	0.9
-25 to +900	0.4	0.45	0.7
K NBS (-225 to 1350°C)			
0 to +900	0.4	0.45	0.7
+900 to 1350	0.52	0.65	1.3
T NBS (-230 to 400°C)			
-100 to +75	0.58	0.65	1.1
+75 to +150	0.35	0.39	0.7
+150 to +400	0.3	0.34	0.6
T DIN (-200 to 600°C)			
0 to +200	0.48	0.53	0.8
+200 to +600	0.37	0.41	0.7

	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
E NBS (-250 to 838°C)			
-100 to -25	0.47	0.54	0.9
-25 to +750	0.3	0.33	0.6
+750 to +810	0.33	0.4	0.8
R NBS (0 to 1767°C)			
+250 to +450	0.9	1.0	1.3
+450 to +1767	0.8	0.9	1.4
S NBS (0 to 1767°C)			
+200 to +1767	0.97	1.1	1.6
B NBS (200 to 1820°C)			
+600 to +800	1.4	1.6	1.9
+800 to +1820	0.96	1.1	1.3
N NBS (-200 to 400°C) (For 28-gauge thermocouple wire)			
-100 to +150	0.6	0.7	1.1
+150 to +400	0.4	0.44	0.7
C HOS (0 to 2315°C)			
+200 to +1000	0.57	0.66	0.94
+1000 to +2000	0.9	1.2	2.1
+2000 to +2315	1.3	1.7	2.9

Temperature Measurement Using Thermocouples (-165 A/D Converter)

Hardware Used ..... -165 Fast A/D Converter
-175 Isothermal Input Connector

Accuracy In $\pm^{o}$C (Continuous Scan Mode)

Thermocouple Type (Sensor Temperature Range) Sensor Temperature (^{o}C)	Time Since A/D Calibration (Operating Temperature in ^{o}C) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
J NBS (-200 to 760^{o}C)			
-100 to -25	1.11	1.16	2.46
-25 to +760	0.95	1.0	2.04
J DIN (-200 to 900^{o}C)			
-100 to -25	1.13	1.17	2.5
-25 to +900	0.9	0.98	2.04
K NBS (-275 to 1350^{o}C)			
0 to 900	1.2	1.33	2.83
900 to 1350	1.51	1.7	3.6
T NBS (-230 to 400^{o}C)			
-100 to 75	1.3	1.35	3.0
75 to +150	0.95	1.0	2.05
+150 to +400	0.85	0.9	1.9
T DIN (-200 to 600^{o}C)			
0 to +200	1.04	1.07	2.3
+200 to +600	0.82	0.85	1.81

	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
E NBS (-250 to 838°C)			
-100 to -25	1.1	1.15	2.4
-25 to +810	0.88	0.94	1.93
R NBS (0 to 1767°C)			
+250 to +450	3.0	3.0	7.0
+450 to +1767	2.71	2.76	6.3
S NBS (0 to 1767°C)			
+200 to +1767	3.26	3.3	7.7
B NBS (200 to 1820°C)			
+600 to +800	4.3	4.3	10.3
+800 to +1820	3.4	3.42	8.12
N NBS (-200 to 400°C) (For 28-gauge thermocouple wire)			
-100 to +150	1.7	1.75	3.9
+150 to +400	1.17	1.2	2.55
C HOS (0 to 2315°C)			
200 to 1000	1.86	2.0	4.43
1000 to 2000	3.0	3.35	7.4
2000 to 2315	4.1	4.55	10.1

Resolution: 0.1°C on Base Metal Thermocouples
0.5°C on Noble Metal Thermocouples
(R, S, B, C)

Accuracy (Burst Scan Mode)

Add the following to Continuous Scan Mode figures:

THERMOCOUPLE TYPE	ADD:
J,K,T,E	0.3°C
R,S,B,C	1.0°C

Temperature Measurement Using RTDs

Hardware Used ..... -161 High Performance A/D
-163 RTD/Resistance Scanner
-177 RTD/Resistance Input Connector

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	90 Days Since A/D Calibration, 18 to 28°C Operating Temperature, Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)			
-200 to 150	0.09°C*	0.006°C	0.03°C
150 to 425	0.13°C	0.006°C	0.04°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)			
-200 to 600	0.25°C	0.05°C	0.14°C
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.28°C	0.06°C	0.16°C
Platinum 385 DIN, 3-Wire Accurate (3WA)			
	+0.007°C**		+0.001°C**
10 Ohm Copper, 3-Wire Accurate (3WA)			
	+0.065°C**		+0.008°C**

NOTES:

* An ice-point initialization allows 385 DIN RTDs to have an accuracy of 0.05°C + probe conformity.

** Add °C per ohm lead resistance to 4W specifications.

	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, 3-Wire Isolated (3WCM)			
	±1.97°C***		±1.97°C***
10 Ohm Copper, 3-Wire Isolated (3WCM)			
	±18.2°C***		±18.2°C***
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)			
	±0.8°C***		±0.8°C***

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)			
-200 to 150	0.10°C	0.006°C	0.04°C
150 to 425	0.15°C	0.006°C	0.04°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)			
-200 to 600	0.27°C	0.05°C	0.16°C

*** NOTE: Add °C to 3WA specifications.

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.3°C	0.06°C	0.16°C
Platinum 385 DIN, 3-Wire Accurate (3WA)	+0.007°C**		+0.001°C**
10 Ohm Copper, 3-Wire Accurate (3WA)	+0.065°C**		+0.008°C**
Platinum 385 DIN, 3-Wire Isolated (3WCM)	+1.97°C***		+1.97°C***
10 Ohm Copper, 3-Wire Isolated (3WCM)	+18.2°C***		+18.2°C***
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)	+0.8°C***		+0.8°C***

NOTES:
** Add °C per ohm lead resistance to 4W specs
*** Add °C to 3WA specs

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	1 Year Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift $dT/dt < 1^{\circ}C$ / 10min ACCURACY	 RESOLUTION
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)		
-200 to 150	0.11°C	0.006°C
150 to 425	0.16°C	0.006°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)		
-200 to 600	0.28°C	0.05°C
10 Ohm Copper, 4-Wire (4W)		
(-75°C to +150°C)	0.3°C	0.06°C
Platinum 385 DIN, 3-Wire Accurate (3WA)		
(full range)	Add 0.008°C per ohm lead resistance to 4W specs	
10 Ohm Copper, 3-Wire Accurate (3WA)		
(full range)	Add 0.073°C per ohm lead resistance to 4W specs	
Platinum 385 DIN, 3-Wire Isolated (3WCM)		
(full range)	Add 2.53°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM)		
(full range)	Add 23.4°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)	Add 1.5°C to 3WA specs	

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	1 Year Since A/D Calibration -20 to 70°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min ACCURACY	RESOLUTION
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)		
-200 to 150	0.19°C	0.006°C
150 to 425	0.29°C	0.006°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)		
-200 to 600	0.44°C	0.05°C
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.4°C	0.06°C
Platinum 385 DIN, 3-Wire Accurate (3WA) (full range)	Add 0.010°C per ohm lead resistance to 4W specs	

10 Ohm Copper, 3-Wire Accurate (3WA)
(full range) Add 0.096°C per ohm lead resistance to 4W specs

Platinum 385 DIN, 3-Wire Isolated (3WCM)
(full range) Add 2.53°C to 3WA specs

10 Ohm Copper, 3-Wire Isolated (3WCM)
(full range) Add 23.4°C to 3WA specs

10 Ohm Copper, 3-Wire Isolated (3WCM)
(Special, modified -163)
Add 1.5°C to 3WA specs

Temperature Measurement Using RTDs (-161 A/D)

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Performance

RTD Type and Scanner Range (sensor temperature range) Sensor Temperature (°C)	90 Days Since Calibration 15 to 35°C Operating Temperature		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN (-200°C to probe limit)			
-200 to 600	0.2°C	0.013°C	0.08°C
10 Ohm Copper (full range)	1.0°C	0.1°C	0.2°C

Temperature Measurement Using RTDs (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-164 Transducer Excitation Module
-174 Transducer Excitation Connector (with current excitation selected)

Performance

RTD Type and Scanner Range (sensor temperature range) Sensor Temperature (°C)	90 Days Since Calibration 15 to 35°C Operating Temperature		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN			
Platinum 392 DIN			
-200 to 125	0.4°C	0.43°C	0.66°C
125 to 600	0.54°C	0.62°C	0.97°C

DC Voltage Measurement Accuracy (-161 A/D)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Accuracy

Range	Internal Resolution (microvolts) 60Hz	50Hz	Time Since A/D Calibration (Operating Temperature in ^{o}C) (± % Input ± microvolts) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
±64 mV	0.6	0.5	0.005% + 7.0	0.01% + 8.0	0.03% + 9.0
±512 mV	5.0	4.2	0.005% + 30	0.01% + 40	0.03% + 50
±8V	73	61	0.005% + 700	0.01% + 800	0.03% + 900
±64V	600	500	0.009% + 3 mV	0.02% + 4 mV	0.05% + 5 mV

DC Voltage Measurement Accuracy (-165 A/D)

Hardware Used ..... -165 Fast A/D Converter
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input

Range	Internal Resolution	Time Since A/D Calibration (Operating Temperature in °C) (± % Input ± uV or mV) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
DIFFERENTIAL INPUTS, CONTINUOUS SCAN MODE				
±64 mV	2 uV	.02% ±25 uV	.03% ±25 uV	.06% ±60 uV
±512 mV	16 uV	.02% ±100 uV	.03% ±100 uV	.06% ±140 uV
±8V	0.25 mV	.02% ±1.2 mV	.03% ±1.2 mV	.06% ±1.5 mV
±10V	0.32 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2 mV
DIFFERENTIAL INPUTS, BURST SCAN MODE				
±64 mV	2 uV	.02% ±35 uV	.03% ±35 uV	.06% ±70 uV
±512 mV	16 uV	.02% ±150 uV	.03% ±150 uV	.06% ±190 uV
±8V	0.25 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
±10.5V	0.32 mV	.02% ±2.2 mV	.03% ±2.2 mV	.06% ±2.5 mV
SINGLE ENDED INPUTS, CONTINUOUS SCAN MODE				
±64 mV	2 uV	.02% ±35 uV	.03% ±35 uV	.06% ±70 uV
±512 mV	16 uV	.02% ±150 uV	.03% ±150 uV	.06% ±190 uV
±8V	0.25 mV	.02% ±1.2 mV	.03% ±1.2 mV	.06% ±1.5 mV
±10.5V	0.32 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
SINGLE ENDED INPUTS, BURST SCAN MODE				
±64 mV	2 uV	.02% ±45 uV	.03% ±45 uV	.06% ±80 uV
±512 mV	16 uV	.02% ±200 uV	.03% ±200 uV	.06% ±240 uV
±8V	0.25 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
±10.5V	0.32 mV	.02% ±2.2 mV	.03% ±2.2 mV	.06% ±2.5 mV

AC Voltage Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-160 AC Voltage Input Connector

Performance

Range and Frequencies	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
5V to 250V ac rms, 45 Hz to 450 Hz	0.1V	±1% Input ±.1V

DC Current Measurement Accuracy (-161 A/D)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-171 Current Input Connector

Performance

Range	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
±64 mA	0.6 uA	±.25% ±4 uA

DC Current Measurement Accuracy (-165 A/D)

Hardware Used ..... -165 Fast A/D Converter
-176 Voltage Input Connector, or
-175 Isothermal Input Connector

641449 (Fluke Part Number)
Shunt Resistors (mounted on connector screw terminals): 8 ohm, ±0.25%

Performance

Range	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
±64 mA	2 uA	±0.3% ±12 uA

Resistance Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-163 RTD/Resistance Scanner
-177 RTD/Resistance Input Connector

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration 18 to 28°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min			
	(mohm)		(±% Input ± mohm)	
	RESOLUTION 60Hz	50Hz	ACCURACY	REPEATABILITY
256 ohm, 4-Wire (4W)	2.4	2.0	0.0142% + 5.7	0.0037% + 5.7
2048 ohm, 4-Wire (4W)	19	16	0.0137% + 38	0.0032% + 38
64 kilohm, 4-Wire (4W)	600	500	0.055% + 1.2 ohm	0.0040% + 1.2 ohm**
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.4 mohm per ohm lead resistance to 4W specs	Add 0.2 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.7 ohm to 3WA specs	Add 0.7 ohm to 3WA specs

**Humidity 15%RH less than listed for the -163 Scanner

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min			
	(mohm)		(±% Input ± mohm)	
	RESOLUTION 60Hz	50Hz	ACCURACY	REPEATABILITY
256 ohm, 4-Wire (4W)	2.4	2.0	0.0170% + 5.7	0.0065% + 5.7
2048 ohm, 4-Wire (4W)	19	16	0.0165% + 38	0.0060% + 38
64 kilohm, 4-Wire (4W)	600	500	0.06% + 1.2 ohm	0.0075% + 1.2 ohm**
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.5 mohm per ohm lead resistance to 4W specs	Add 0.3 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.7 ohm to 3WA specs	Add 0.7 ohm to 3WA specs

**Humidity 15%RH less than listed for the -163 Scanner

Performance

Scanner Range and Measurement Mode	1 Year Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min		
	(MILLIOHMS) RESOLUTION 60Hz	50Hz	ACCURACY
256 ohm, 4-Wire (4W)	2.4	2.0	±.0175% Input ±5.7 mohm
2048 ohm, 4-Wire (4W)	19	16	±.0170% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600	500	±.06% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.8 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.9 ohm to the 3WA specifications

Performance

Scanner Range and Measurement Mode	(MILLIOHMS) RESOLUTION 60Hz	50Hz	ACCURACY 1 Year Since A/D Calibration -20 to 70°C Operating Temperature Temperature Shift dT/dt < 1°C / 10 min
256 ohm, 4-Wire (4W)	2.4	2.0	±.0365% Input ±7 mohm
2048 ohm, 4-Wire (4W)	19	16	±.0360% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600	500	±.23% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W		Add 3.7 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.9 ohm to the 3WA specifications

Resistance Measurement Accuracy (-161 A/D)

Hardware Used .... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
- -175 Isothermal Input
- -176 Voltage Input
- -160 AC Voltage Input

-164 Transducer Excitation Module
-174 Transducer Excitation Connector (with current excitation selected)

Performance

Range	90 Days Since Calibration 15 to 35°C Operating Temperature		
	(MILLIOHMS) RESOLUTION 60Hz	50Hz	ACCURACY
64 ohm	0.6	0.5	±.02% Input ±7 mohm
512 ohm	5.0	4.2	±.02% Input ±30 mohm

Resistance Measurement Accuracy (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
-175 Isothermal Input Connector, or
-176 Voltage Input Connector
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)

Performance

Range	90 Days Since Calibration 15 to 35°C Operating Temperature (MILLIOHMS) RESOLUTION	ACCURACY
64 ohm	2.0	±0.035% Input ±25 mohm
512 ohm	16.0	±0.035% Input ±100 mohm

Strain Measurement Accuracy (-161 A/D)

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with voltage excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Bridge Type	90 Days Since Calibration 20 to 30°C Operating Temperature	
	RESOLUTION	ACCURACY
Full Bridge	0.25 uE	±.05% Input ±2 uE
1/2 Bridge	0.5 uE	±.05% Input ±13 uE
1/4 Bridge	0.5 uE	±.05% Input ±25 uE

Strain Measurement Accuracy (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
-175 Isothermal Input Connector, or
-176 Voltage Input Connector
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)

Performance

Bridge Type	90 Days Since Calibration, 20 to 30°C Operating Temperature		
	RESOLUTION	ACCURACY	TEMPERATURE COEFFICIENT (in ACCURACY)
Full Bridge	1.0 uE	±0.1% Input ±6 uE	
1/2 Bridge	2.0 uE	±0.1% Input ±18 uE	±2 uE/°C
1/4 Bridge	2.0 uE*	±0.1% Input ±30 uE	±4 uE/°C

* Assume use of 4V excitation.

Section 2A
Performance Testing

CONTENTS

MAINFRAME PERFORMANCE TESTING

Overall mainframe performance tests, which can also be used as initial acceptance tests, are presented below. Complete all steps in this procedure for a complete performance test. But note that this procedure includes three types of test, any one of which can be completed separately. The steps involved for each type of test are:

- Interface Test: Steps 1 through 8
- Alarm Annunciator Test: Steps 9 through 29
- Printer Output Test: Steps 30 through 34

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Table 2A-1 specifies test equipment called for in the following tests. Use this table for both the mainframe tests immediately following and the individual option assembly tests later in this section.

Usually, the performance test for one option assembly requires that at least one other option assembly be used. This type of interlocking requirement is defined in Table 2A-2.

Table 2A-1. Summary of Required Test Equipment

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Voltage Calibrator	+31.3 mV ±20 uV +2.048V ±50 uV -2.048V ±2 uV of +2.048 500 mV ±20 uV 6.2V ±155 uV 6.8V ±0.1V 5.0V ±100 uV 7.9V ±200 uV 63V ±800 uV 1.008V ±40 uV	Fluke Model 343
Digital Multimeter DMM	Capable of measuring +12V dc	Fluke 77 or equivalent
Meter Calibrator	10.0V ±0.01V	Fluke 5100B
Power Supply	Capable of sourcing +12V dc	Appropriate lab type
100:1 Divider	±0.005%	Fluke Accessory Y2022

Table 2A-1. Summary of Required Test Equipment (cont)

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Voltmeter	+10V ±0.06V 50.0 mV ±0.001 mV 500.0 mV ±0.005 mV	Fluke Model 8505A
Resistance Calibrator	n/a	Fluke 5450A
Resistor (4 each)	100 ohm 0.01% 5ppm/°C	Fluke Part No. 491720
Resistor (2 each)	100 ohm 0.1%	Fluke Part No. 357400
Resistor	499 ohms 1% MF	Fluke Part No. 289256
Resistor (2 each)	220 ohms, 1W	Fluke Part No. 109462
Resistor	1 kilohm ±5%, 1/2W	Fluke Part No. 108597
Resistor	3 kilohm ±5%, 1/2W	Fluke Part No. 109090

Table 2A-1. Summary of Required Test Equipment (cont)

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Resistor	10 kilohm ±5%, 1/2W	Fluke Part No. 109165
Resistor	8 ohm ±0.25%, 1/2W	Fluke Part No. 641449
Thermocouple	Type J or K	Fluke P-20J or P-20K
Oil or Water Bath	n/a	
Mercury Thermometer	0.02 °C resolution	Princo ASTM-56C
Calibration Extender/Fixture	n/a	Fluke Accessory Part No. 648741 (no substitute)
Digital Extender Assembly	n/a	2400A-4021 Fluke Part No. 486910
Toggle Switch	Single-pole, double-throw	Fluke Part No. 493825

Table 2A-2. Hardware Requirements

FUNCTIONS	HARDWARE REQUIRED
DC VOLTS	
High Performance A/D Converter	
1	-161, -162/-175
2	-161, -162/-176
3	-161, -162/-160
Fast A/D Converter	
1	-165/-175
2	-165/-176
THERMOCOUPLE	
High Performance A/D Converter	-161, -162/-175
Fast A/D Converter	-165/-175
RTD	
High Performance A/D Converter	
1	-161, -162/-175, -164/-174
2	-161, -162/-176, -164/-174
3	-161, -163/-177
Fast A/D Converter	
1	-165/-175, -164/-174
2	-165/-176, -164/-174
THERMISTOR	
High Performance A/D Converter	-161, -163/-177
DC CURRENT	
High Performance A/D Converter	-161, -162/-171
Fast A/D Converter	
1	-165/-175, 8-ohm shunt resistor
2	-165/-176, 8-ohm shunt resistor
STRAIN	
High Performance A/D Converter	
1	-161, -162/-175, -164/-174
2	-161, -162/-176, -164/-174
Fast A/D Converter	
1	-165/-175, -164/-174
2	-165/-176, -164/-174
AC VOLTS	
High Performance A/D Converter	-161, -162/-160
FREQUENCY	-167

Table 2A-2. Hardware Requirements (cont)

FUNCTIONS	HARDWARE REQUIRED
TOTALIZING	-167
ANALOG OUTPUT	-170
BINARY/BCD INPUTS	-168/-169
STATUS INPUT	-168/-169
STATUS OUTPUT	-168/-179

("/-" before number shows options attaching directly)

To verify that the Front End mainframe has been correctly installed and is operating properly, perform the following:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Ensure that communication parameters (i.e., transmission mode, baud rate, parity, number of data bits, number of stop bits) on the Front End and the host (terminal or computer) are properly configured to send and receive serial data.

This is done by following the instructions under the heading "Setting the Communication Switches" in Section 3A of the Helios Plus System Manual. If the Computer Interface Assembly was removed to check (or set) the communication parameters, reinstall it at this time.

3. Remove all installed options from the Front End.

4. Directly connect the host terminal to the Front End using equipment and cables appropriate to the type of electrical interface (RS-232-C or RS-422).

   Check to make sure connections are tight.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Switch ON power to the host.

7. Using a terminal or a computer emulating a terminal as the selected host, send the following commands to the Front End.

   MODE=TERM <CR>
   SEND VERSION$ <CR>

   The response from the Front End to the host should be:

Helios Plus Version x.y Software by John Fluke Mfg. Inc.

   Note that x.y is the version number of the installed firmware. If this response is not returned a malfunction has occurred.

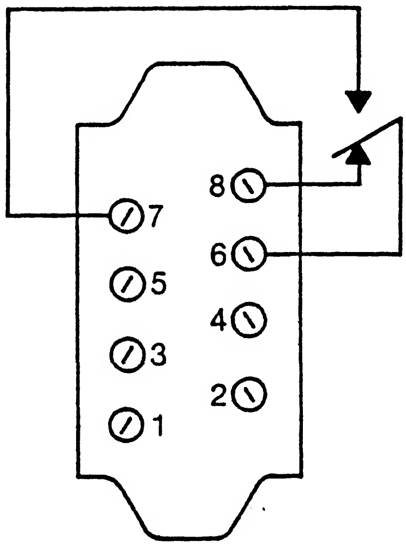
8. This completes the Mainframe Interface Test.

If the Front End has failed this test, check all connections, then perform the test again. If the system fails the test a second time, determine if the interface of the host is functioning properly by testing it with another system or device. If the host interface is not at fault, contact your nearest Fluke Service Representative (see Appendix B).

NOTE

The following steps verify operation of the Alarm Annunciator Assembly. Because this test is dependent on voltage readings, the accuracy verification test of either the -162 Thermocouple/DC Volts Scanner or -165 Fast A/D Converter (whichever option is being used) should be performed if voltage readings are suspect.

9. Wire an Alarm Acknowledgement Switch (single pole, double throw) to the Alarm Annunciator Terminal Strip as shown in Figure 2-1.



WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT ALL EXTERNAL POWER SOURCES BEFORE MAKING ANY ALARM CONNECTIONS.

Figure 2-1. Alarm Annunciator Test

10. The following steps can be accomplished using either the -161 A/D Converter or the -165 Fast A/D Converter. Perform the appropriate step (a or b) below:

    a. Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

    b. Set the -165 Fast A/D Converter address switches to "00" and install into the top option slot of the Front End.

11. Remove all other installed options to eliminate addressing conflict.

12. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

    Depending on which option was used in step 10, install the connector either on the -162 Scanner or on the -165 Fast A/D Converter.

13. Reconnect the Front End's ac line cord and switch the power ON.

14. Connect the DC Voltage Calibrator output to the input connector test leads.

15. Set the calibrator output to 3.0000 volts dc.

NOTE

Prior to performing steps 16 and 17, check that the terminal screws are tightened securely. This check ensures good continuity.

16. With the DMM set to a resistance function, measure for an OPEN across terminals 1 and 3 (audible contacts) of the Alarm Annunciator Terminal Strip.

17. Move the DMM test leads across terminals 2 and 4 (visual contacts) of the Alarm Annunciator Terminal Strip. Check that an OPEN is measured.

18. Using a terminal or a computer emulating a terminal, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5 <CR>
FORMAT=XASCII <CR>
SEND CHAN(0) <CR>
```

NOTE

The accuracy of the value returned for channel(000) is dependent on the type a/d converter, as follows:

A -161 and -162 system should return 3.00000E+00 +/- 0.0012 V.

A -165 system should return 3.00000E+00 +/- 0.0021 V.

19. Repeat steps 16 and 17, checking that relay contacts remained OPEN.

20. Set the calibrator to output 4.2000 Volts dc.

21. Again send the command:

```
SEND CHAN(0) <CR>
```

The response for channel 0 should be approximately 4.20000E+00 with the text "hi alarm" appended.

22. Using the DMM as an ohmmeter, measure a contact closure across terminals 1 and 3 (audible contacts) of the Alarm Annunciator Terminal Strip.

23. Move the DMM test leads to measure across terminals 2 and 4 (visual contacts). The DMM should indicate closure and opening of the contacts at approximately an 800 millisecond rate.

24. Acknowledge the alarm by switching the Alarm Acknowledgement Switch so that its normally open (N/O) contact makes continuity with common, then switch back to the normally closed (N/C) position.

25. With the DMM, check that an OPEN is measured across the audible contacts (terminals 1 and 3).

26. Move the DMM test leads to measure across the visual contacts (terminals 2 and 4). They should now be shorted (closed).

27. Set the calibrator to output 3.8000 Volts dc.

28. Command the Front End to take another measurement on channel 0 by issuing the following command:

    SEND CHAN(0) <CR>

    Verify the response is approximately 3.80000E+00 without any alarm message.

29. Check that both the audible (terminals 1 and 3) and the visual (terminals 2 and 4) contacts now measure an OPEN.

30. The following steps verify that the Printer Port is functioning properly.

NOTE

Switch S4 on the Computer Interface Assembly must be configured to match the communication parameters of the printer or display monitor.

31. Using an RS232 null modem cable (Y1702 or equivalent) connect an RS232 printer or display monitor to the printer port of the Helios Plus Computer Interface Module. Check that power to the device is turned ON.

32. Using a terminal or a computer emulating a terminal, send the following commands to the Front End.

```
MODE=TERM <CR>
COUNT=OFF <CR>
FORMAT=XASCII <CR>
DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5 <CR>
DEF SCAN(0)=CHAN(0) <CR>
START SCAN(0),OUTPUT=PRINTER,INTERVAL=10 <CR>
```

33. Check that the Printer Port outputs SCAN(0) information at a ten second interval.

    SCAN information will include: Date, Time, Scan(#), Chan(#), Measured Value, and Status (if an error or alarm occurs).

34. Send the command: STOP SCAN(0) <CR>

    Printer port output should now cease.

35. This completes Mainframe Performance Testing.

AC VOLTAGE INPUT CONNECTOR (-160)

The following test verifies that the AC Voltage Input Connector is fully functional and within specifications.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the AC Volt Input Connector. Install the connector on the scanner.

4. Reconnect the Front End's ac line cord, and switch the power ON.

5. Using the Fluke 5100B as an ac calibrator, connect the output to the HI and LO test leads of the AC Voltage Input Connector installed on the scanner.

6. Set the calibrator output to 10.00V, 60 Hz.

7. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0..9)=AVIN <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0) <CR>
   ```

   The value returned for the selected channel should be 10.00V +/- 0.2V (1.00000E+01).

8. Set the calibrator output to 0. Move the AC Voltage Input Connector test leads to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining ac input channel (1 through 9), substituting the appropriate channel number in the SEND CHAN command.

10. The ac portion of the AC Voltage Input Connector performance test is complete.

11. To test the dc voltage input channels (channels 10 through 19), perform the -176 Voltage Input Connector performance test.

HIGH PERFORMANCE A/D CONVERTER (-161)

There are four performance tests for the -161 A/D Converter. All four tests may be performed in sequence to verify overall operation of the A/D Converter, or the tests may be run independently.

The four performance tests are:

- Address Response Test
- Accuracy Verification Test
- Overrange Indication Test
- Open Thermocouple Response Test

These performance tests verify that the A/D Converter performs properly and that it meets all specified accuracy tolerances. If calibration of the assembly is required, refer to the Calibration procedures in the Helios Plus Service Manual.

Address Response Performance Test

The Address Response performance Test checks to see if the Front End mainframe controller can communicate properly with the A/D Converter address switch set to a variety of positions that exercise all address switch lines. (Address switch settings and channel ranges for the A/D Converter are shown on Table 2A-3.)

Table 2A-3. A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
0	0 through 99
1	100 through 199
2	200 through 299
3	300 through 399
4	400 through 499
5	500 through 599
6	600 through 699
7	700 through 799
8	800 through 899
9	900 through 999

To conduct the Address Response Performance Test, perform the following procedure:

1. Switch OFF power to the Front End.
2. Disconnect the ac line power cord and all other high voltage inputs.
3. Set the A/D Converter address switch to "0" and install the A/D Converter in the Front End option slot second from the bottom. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.
4. Remove all other installed options to eliminate addressing conflict.

5. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

6. Reconnect power to the Front End and switch power ON.

7. Connect the calibrator output to the input connector test leads.

8. Set the calibrator output to 7.9000V dc.

9. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   ```
   MODE=TERM  <CR>
   DEF CHAN(0)=DVIN,MAX=7.9  <CR>
   FORMAT=DECIMAL  <CR>
   SEND CHAN(0)  <CR>
   ```

   The value returned for the selected channel should be approximately 7.9V.

10. Switch Front End power OFF.

11. Using a common screwdriver, set the address switch on the A/D Converter to "1". Switch power to the Front End ON.

12. Program the Front End to take a measurement on channel 100 by substituting channel "100" for "0" in both the DEF CHAN and SEND CHAN commands of step 9.

13. Repeat steps 10 through 12 for channel 200 (a/d address set to 2), 400 (a/d address set to 4), 800 (address set to 8), and 1400 (address set to 14). The measurement on each channel should be approximately 7.9V.

14. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Accuracy Verification Test

All voltage readings taken by the Front End depend on the accuracy of the A/D Converter. The Accuracy Verification Test checks the A/D Converter to see if its voltage measurement accuracy is within specifications.

To conduct the Accuracy Verification Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volt Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on either the -176 Voltage Input Connector or the -175 Isothermal Input Connector. Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

6. Set the calibrator output to 6.2000V (62 mV out of the divider).

7. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

```
MODE=TERM <CR>
DEF CHAN(0)=DVIN, MAX=0.062 <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0) <CR>
```

   The returned value for channel 0 should be 62 mV +/- 0.014 mV.

8. Change to the 512 mV voltage range by redefining channel 0. Send the following command:

```
DEF CHAN(0)=DVIN, MAX=0.5 <CR>
```

9. Set the calibrator to 0. Remove the 100:1 divider and connect the calibrator output directly to the connector test leads on channel 0.

10. Set the calibrator to output 500 mV.

11. Request a measurement and verify that channel 0 returns a value of 500 mV +/- 0.1 mV. Send:

```
SEND CHAN(0) <CR>
```

12. Change to the 8V range by redefining channel 0. Send:

```
DEF CHAN(0)=DVIN, MAX=7.9
```

13. Set the calibrator output to 7.9000V.

14. Request another measurement as in step 11.

    Verify that the returned value is within 7.9V +/- 0.002V.

15. Change to the 64V range by redefining channel 0. Send the following command:

    DEF CHAN(0)=DVIN, MAX=63 <CR>

16. Set the calibrator output to 63.000V.

17. Request another channel 0 measurement.

    The returned value should be 63V +/- 0.02V.

18. The Accuracy Verification Test is now complete.

Continue with the Overrange Indication Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Overrange Indication Test

The Overrange Indication Test determines if the A/D Converter can detect and communicate a channel overrange condition to the mainframe controller.

To conduct the Overrange Indication Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End.

   Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider.

   Connect the divider output to the input connector test leads.

6. Set the calibrator output to 6.8V (68 mV out of the divider).

7. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0)=DVIN,MAX=0.062 <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0) <CR>
   ```

   The value displayed for channel 0 should be 9.99999E+37.

8. Send the following command to inspect the fault condition:

   ```
   LIST ERROR <CR>
   ```

   The following error message should be displayed:

   Chan(0)-Out of range

9. The Overrange Test is complete.

Continue with the Open Thermocouple Response Test if you are conducting a complete performance test of the -161 High Performance A/D Converter and you have not already performed the test in the Thermocouple/DC Volt Scanner performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test determines if the A/D Converter can detect and communicate an open thermocouple condition on a channel to the mainframe controller.

NOTE

The Open Thermocouple Response Test is part of the performance test for the -162 Thermocouple/DC Volts Scanner. The test is repeated here because each assembly contains part of the circuitry that checks for an open thermocouple. If both the A/D Converter and the Thermocouple/DC Volts Scanner are being tested, the open thermocouple test need only be performed once.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test leads from the Isothermal Input Connector to a 1-kilohm resistor.

6. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   MODE=TERM <CR>
   DEF CHAN(0)=TC,TYPE=JNBS <CR>
   FORMAT=DECIMAL <CR>
   TUNIT=CELSIUS <CR>
   SEND CHAN(0) <CR>

   The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

7. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate a high resistance or open thermocouple.

8. Request a measurement and verify that the returned value is:

   9.99999E+37

9. Send the following command to inspect the fault condition:

   LIST ERROR <CR>

   The following error message should be displayed:

   chan(0)-open tc

10. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

11. Performance testing of the -161 High Performance A/D Converter is complete.

THERMOCOUPLE/DC VOLTS SCANNER (-162)

Three performance tests, which can be performed separately or together, verify that the Thermocouple/DC Volts Scanner is operational and meets its accuracy specifications.

NOTE

Since the Thermocouple/DC Volts Scanner must be used with the -161 A/D Converter, the A/D Converter must be tested and calibrated first.

The three performance tests are:

- o Channel Integrity Test
- o Accuracy Verification Test:
- o Open Thermocouple Response Test:

These performance tests verify that the Thermocouple/DC Volts Scanner meets specified accuracy tolerances on all channels. If the scanner fails one of the tests, it must be repaired or replaced since there are no calibration adjustments on the scanner.

Channel Integrity Test

The Channel Integrity Test verifies that each scanner channel is functional. Use the following procedure to perform this test:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the address switch on an -161 A/D Converter to 0, and install it in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner to be tested in the option slot just below the A/D Converter.

3. Connect a pair of test leads to the HI and LO terminals of Channel 0 of a -175 or -176 input connector. Install the input connector on the scanner.

4. Reconnect the ac line cord to the Front End, and switch the power ON.

5. Connect the calibrator output to the input connector test leads.

6. Set the calibrator output to 7.9000V dc.

7. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

```
MODE=TERM  <CR>
DEF CHAN(0..19)=DVIN,MAX=7.9  <CR>
FORMAT=DECIMAL  <CR>
SEND CHAN(0)  <CR>
```

   The value returned for the selected channel should be 7.9V +/- 0.002V.

8. Set the calibrator output to zero. Move the input connector test leads to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining voltage input channel (1 through 19). Substitute the appropriate channel number in the SEND CHAN command.

10. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are performing a complete verification of the scanner and you have not already performed the test as part of the performance testing of the A/D Converter.

Accuracy Verification Test

The Accuracy Verification Test checks scanner accuracy against specifications. Because all voltage readings returned by the Front End are dependent upon the accuracy of the A/D Converter, the A/D Converter must be calibrated before performing this test.

Use the following procedure to perform the Accuracy Verification Test:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End.

   Install a scanner in the slot just below the A/D Converter.

3. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or on a -175 Isothermal Input Connector.

   Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 Voltage Divider. Connect the output of the divider to the scanner input connector test leads.

6. Set the calibrator to output 6.2000V (62 mV out of the Voltage Divider).

7. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0)=DVIN, MAX=0.062
   FORMAT=DECIMAL <CR>
   SEND CHAN(0) <CR>
   ```

   The returned value for channel 0 should be 62 mV +/- 0.014 mV.

8. Change to the 512 mV voltage range by redefining channel 0. Send the command:

   ```
   DEF CHAN(0)=DVIN, MAX=0.5 <CR>
   ```

9. Set the calibrator to 0. Remove the 100:1 divider, and connect the calibrator output directly to the connector test leads on channel 0.

10. Set the calibrator to output 500 mV.

11. Take a measurement on channel 0. It should return a value of 500 mV +/- 0.1 mV. Send the following command:

    ```
    SEND CHAN(0) <CR>
    ```

12. Change to the 8V range by redefining channel 0. Send the command:

    ```
    DEF CHAN(0)=DVIN, MAX=7.9 <CR>
    ```

13. Set the calibrator output to 7.9000V.

14. Take another measurement as described in step 11. Verify that the returned value is 7.9V +/- 0.002V.

15. Change to the 64V range by redefining channel 0. Send the command:

    DEF CHAN(0)=DVIN, MAX=63 <CR>

16. Set the calibrator output to 63.000V.

17. Take a measurement on channel 0. The returned value should be 63V +/- 0.02V.

18. The Accuracy Verification Test is now complete.

Continue with the Open Thermocouple Response Test if you are performing a complete verification test of the scanner and you have not already performed the test in the A/D Converter performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test checks whether the A/D Converter and scanner respond with an open thermocouple indication when presented with an open thermocouple channel input.

NOTE

This test is also one of the A/D Converter performance tests. It is repeated here because both the scanner and the A/D contain the circuitry which senses open thermocouple conditions. The test need not be repeated if it was performed previously.

Use the following procedure to perform the Open Thermocouple Response Test:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to "0" and install the A/D in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

3. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test leads from the Isothermal Input Connector to a 1 kilohm resistor.

6. Using a terminal (or a computer emulating a terminal) as the selected host, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0)=TC,TYPE=JNBS <CR>
   TUNIT=CELSIUS <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0) <CR>
   ```

   The value returned for channel 0 should be equal to the ambient temperature +/- 2 degrees Celsius.

7. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate a high resistance or open thermocouple.

8. Request a measurement and verify that the returned value is:

   9.99999E+37

9. Send the following command to inspect the fault condition:

   LIST ERROR <CR>

   The following error message should be displayed

   chan(0)-open tc

   meaning that a temperature measurement was attempted with a damaged or improperly connected thermocouple.

10. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

    Performance testing of the Thermocouple/DC Volts Scanner is complete.

RTD/RESISTANCE SCANNER (-163)

Six tests are conducted to verify that the RTD/Resistance Scanner is operating properly and meets specifications in all modes and operating ranges. These tests can be used as an initial acceptance test or as a troubleshooting aid. Equipment required to perform the following tests is listed in Table 2A-1.

Performance Test Preparation

Perform the following preparation procedure:

1. Wire an RTD/Resistance Input Connector as shown in Figure 2A-2, with all connections to R1, R2, and R3 made to the resistor leads. (See Table 2A-1 for resistor specifications.)

2. Switch OFF power to the Front End and disconnect the ac line cord and all other high voltage inputs.

3. Set the -161 High Performance A/D Converter address switch to "0" and install the A/D Converter in the top Front End option slot.

4. To prevent addressing conflicts, remove all other installed options.

5. Set jumpers W1 and W2 of the RTD/Resistance Scanner for 4W operation, and install the scanner in the option slot immediately below the A/D Converter. See Figure 2A-3.

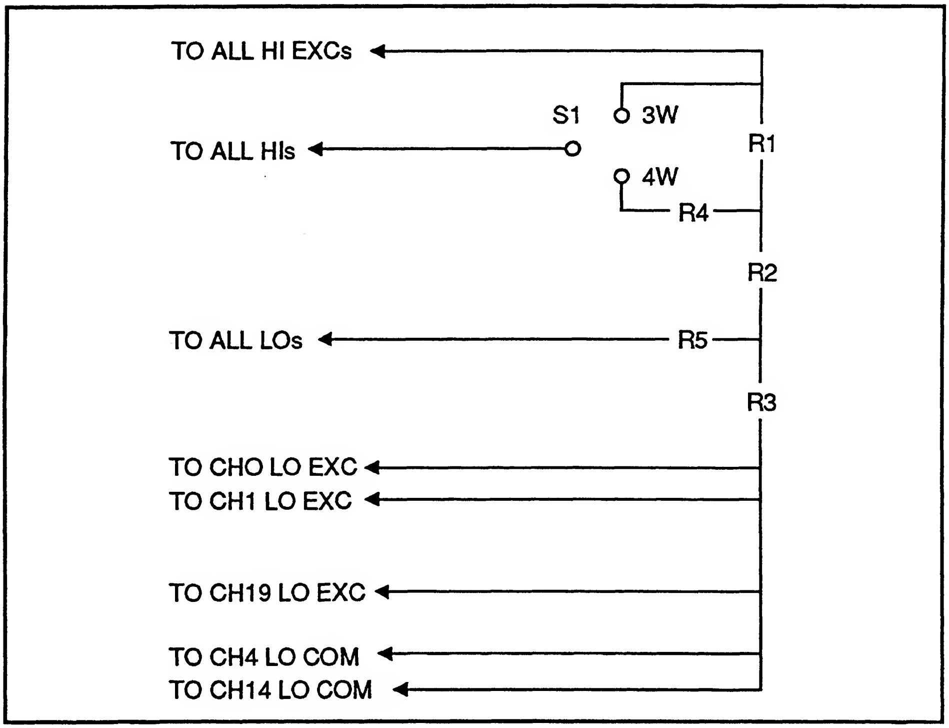


Figure 2A-2. Test Input Connector Schematic

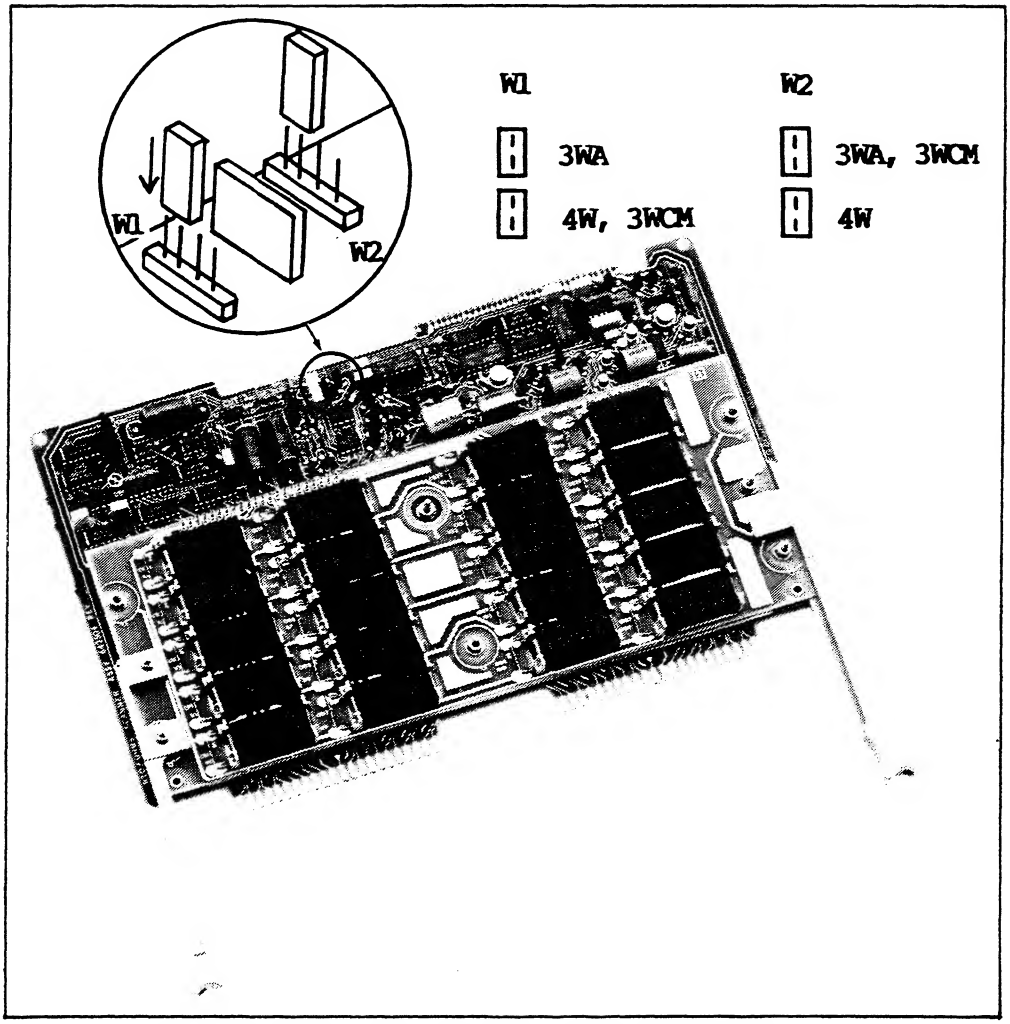


Figure 2A-3. W1 and W2 Jumper Settings

6. Set S1 of the Test Input Connector to the 4W position, and install the connector on the RTD/Resistance Scanner.

7. Reconnect the ac line cord to the Front End and switch the power ON.

Performance Test Procedures

The following six tests will be performed:

- Serial Link Communication Test
- 256-Ohm Range, 4-Wire Mode Test
- 2048-Ohm Range, 4-Wire Mode Test
- 64-Kilohm Range, 4-Wire Mode Test
- 256-Ohm Range, 3WA Mode Test
- 256-Ohm Range, 3WCM Test

To conduct these tests, the Front End must be programmed using a terminal. (You can also run a terminal emulation program to use a computer behaving as a terminal.)

SERIAL LINK COMMUNICATION TEST

1. Send the following commands to the Front End:

```
MODE=TERM  <CR>
RESET CHAN(0..19)  <CR>
LIST CHAN(0..19)  <CR>
```

2. A listing for each of the 20 designated channels should be returned as follows:

```
aichan(0)=R, def=off
     .
     .
     .
aichan(19)=R, def=off
```

250-OHM RANGE, 4-WIRE MODE TEST

1. Ensure the RTD/Resistance Scanner's W1 and W2 jumpers are set for 4W operation. See Figure 2A-3.

2. Ensure that the Test Input Connector switch S1 is set to 4W.

3. Send the following commands to the Front End:

```
FORMAT=DECIMAL <CR>
DEF CHAN(0..19)=RESIST, MAX=100 <CR>
SEND CHAN(0..19) <CR>
```

The returned channel readings should be between 99.964 and 100.036 ohms.

2048-OHM RANGE, 4-WIRE MODE TEST

1. Send the following commands to the Front End:

```
DEF CHAN(0..19)=RESIST, MAX=2000 <CR>
SEND CHAN(0..19) <CR>
```

2. The returned channel readings should be between 99.930 and 100.070 ohms.

64K-OHM RANGE, 4-WIRE MODE TEST

1. Send the following commands to the Front End:

```
DEF CHAN(0..19)=RESIST, MAX=6000 <CR>
SEND CHAN(0..19) <CR>
```

2. The readings should now be between 98.700 and 101.300 ohms.

256-OHM RANGE, 3WA MODE TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WA operation. See Figure 2A-3.

3. Set S1 of the Test Input Connector to the 3W position.

4. Reinstall both the RTD/Resistance Scanner and Test Input Connector in below the A/D Converter. Switch the power ON.

5. Send the following commands to the Front End:

```
DEF CHAN(0..19)=RESIST, MAX=100 <CR>
SEND CHAN(0..19) <CR>
```

The readings should be between 99.743 and 100.257 ohms.

256-OHM RANGE, 3WCM TEST

1. Switch OFF power to the Front End, and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WCM operation. See Figure 2A-3.

3. Ensure that S1 of the Test Input Connector is in the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input Connector below the A/D Converter. Switch power ON.

5. Send the following command to the Front End:

```
SEND CHAN(0..19) <CR>
```

The channel readings should be between 99.150 and 100.850 ohms.

This completes performance testing of the -163 RTD/Resistance Scanner.

TRANSDUCER EXCITATION MODULE (-164)

The following performance tests verify that the Transducer Excitation Module and Transducer Excitation Connector are operating properly within specified tolerance.

These tests can be performed using either one of two types of a/d converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

The following two tests are required to verify the proper operation of the assembly:

- Current Excitation Test
- Voltage Excitation Test

The procedures for conducting these tests follow.

Current Excitation Performance Test

To test current excitation, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.
2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate a/d converter to 00.
3. To avoid addressing conflict, remove all other installed options.

4. On the Transducer Excitation Module, set the voltage excitation switch (S1) to the 4V position.

5. Now, referring to the a/d converter-specific instructions below, install the -164 Transducer Excitation Module.

   o -161 High Performance A/D Converter

      a. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the a/d converter.

      b. Install the -164 Transducer Excitation Module in the slot directly below the -162 scanner.

      c. Channels 0 through 19 are addressable with this configuration.

   o -165 Fast A/D Converter

      a. Ensure that the External Trigger Jumper (W1) on the Fast A/D Converter is positioned for normal measurement inputs on channels 0 and 20. Refer to Figure 165-2 in Section 3B of this manual.

      b. Install the -164 Transducer Excitation Module in the slot directly below the Fast A/D Converter.

      c. Channels 0 through 39 are addressable with this configuration.

6. Install the five jumpers on a Transducer Excitation Connector in the current excitation position.

7. Wire the Transducer Excitation Connector to an Isothermal Input or Voltage Input Connector according to the diagram in Figure 2A-4.

8. Install the -174 Transducer Excitation Connector on the -164 Transducer Excitation Module.

9. Install either the -175 Isothermal Input Connector or the -176 Voltage Input Connector on the scanner or the a/d converter, as follows:

   - -161: install the connector on the -162 Thermocouple/DC Volts Scanner.

   - -165: install the connector directly on the Fast A/D Converter.

```
VOLTAGE INPUT CONN                  TRANSDUCER EXCITATION CONN
        or
ISOTHERMAL INPUT CONN
(Channel/Terminal)                  (Channel/Terminal)

0  HI Terminal  0------------0          1  A Terminal
0  LO           0---+--------0          2  D
0  SH           0---+

4  HI Terminal  0------------0          5  A Terminal
4  LO           0---+--------0          6  D
4  SH           0---+

8  HI Terminal  0------------0          9  A Terminal
8  LO           0---+--------0          10 D
8  SH           0---+

12 HI Terminal  0------------0          13 A Terminal
12 LO           0---+--------0          14 D
12 SH           0---+

16 HI Terminal  0------------0          17 A Terminal
16 LO           0---+--------0          18 D
16 SH           0---+
```

Figure 2A-4. Current Excitation Test Wiring Diagram 1

11. Using a terminal or a computer emulating a terminal as the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(0..19)=DVIN,MAX=7.9 <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0,4,8,12,16) <CR>
```

    The measurement returned on each channel (0, 4, 8, 12,and 16) should be between 5.2V and 5.6V.

    If the measurement is outside this range, one of the shunt diodes located on the Transducer Excitation Module may be shorted or open.

12. Switch OFF power to the Front End and remove the previously wired connectors.

    Rewire for channels 0, 4, 8, 12 and 16 as shown for channel 0 in Figure 2A-5.

NOTE

A 499-ohm +/- 1% resistor must be installed between terminals A and D on channels 0, 4, 8, 12, and 16 of the connector.

13. Install the rewired Transducer Excitation Connector on the Transducer Excitation Module, and install the rewired Voltage or Isothermal Input Connector onto either the Thermocouple/DC Volts Scanner or the Fast A/D Converter.

```
VOLTAGE INPUT CONNECTOR              TRANSDUCER EXCITATION
        or                           CONNECTOR
ISOTHERMAL INPUT CONNECTOR

Channel#    Terminal                 Channel#    Terminal

   0           HI   -------------      0           A ---|
                                                        \   499 ohm
                                                        / resistor
   0           LO   -------------      0           D ---|
```

Figure 2A-5. Current Excitation Test Wiring Diagram 2

14. Switch power to the Front End ON.

15. Redefine channels 0 through 19 to measure a dc voltage on the 512 mV range. Send the following command:

    ```
    DEF CHAN(0..19)=DVIN, MAX=0.5  <CR>
    ```

16. Request a measurement on channels 0, 4, 8, 12, and 16.

    The returned readings should be 499 mV, +/- 5.1 mV. This is the voltage drop across the 499-ohm resistor due to the 1 mA excitation. If a more accurate measurement of this current is desired, a digital multimeter (DMM) can be used to measure it directly.

17. This completes the Current Excitation Test.

Voltage Excitation Performance Test

To test voltage excitation, perform the following procedure:

1. Perform the Current Excitation Performance Test if you have not already done so.

2. Switch OFF power to the Front End and remove both the connectors.

3. Move the five jumpers on the Transducer Excitation Connector to the voltage excitation position.

   Rewire as shown in the Figure 2A-6. Connect as shown for channel 0, 4, 8, 12, and 16.

VOLTAGE INPUT CONNECTOR or ISOTHERMAL INPUT CONNECTOR			TRANSDUCER INPUT CONNECTOR	
Channel #	Terminal		Channel #	Terminal
0	HI	--------------------	0	A
0	LO	--------------------	0	D
4	HI	--------------------	4	A
4	LO	--------------------	4	D

Figure 2A-6. Voltage Excitation Test Wiring Diagram

4. Install the rewired Transducer Excitation Connector on the Transducer Excitation Module and install the rewired Voltage or Isothermal Input Connector onto either the Thermocouple/DC Volts Scanner or the Fast A/D Converter.

5. Switch ON power to the Front End.

6. Program the Front End to measure channels 0, 4, 8, 12, and 16 on the 8V range. Use the following commands:

```
MODE=TERM <CR>
DEF CHAN(0..19)=DVIN,MAX=7.9 <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0,4,8,12,16) <CR>
```

   The measured value for each channel should be 4.0V +/- 0.004V.

7. This completes the Voltage Excitation Performance Test.

FAST A/D CONVERTER (-165)

There are four performance tests for the -165 Fast A/D Converter. All four tests may be performed in sequence to verify overall operation of the Fast A/D Converter, or the tests may be run independently.

The four performance tests are:

- Address Response Test
- Accuracy Verification Test
- Overrange Indication Test
- Open Thermocouple Response Test

These performance tests verify that the Fast A/D Converter performs properly and that it meets all specified accuracy tolerances. If calibration of the assembly is required, refer to the Calibration procedures in the Helios Plus Service Manual.

Address Response Performance Test

The Address Response performance test checks to see if the Front End mainframe controller can communicate properly with the Fast A/D Converter address switch set to a variety of positions that exercise all address switch lines. (Address switch settings and channel ranges for the Fast A/D Converter are shown on Table 2-4.

Table 2A-4. Fast A/D Address Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
00	0 through 39
05	50 through 89
10	100 through 139
15	150 through 189
20	200 through 239
25	250 through 289
30	300 through 339
35	350 through 389
40	400 through 439
45	450 through 489
50	500 through 539
55	550 through 589
60	600 through 639
65	650 through 689
70	700 through 739
75	750 through 789
80	800 through 839
85	850 through 889
90	900 through 939
95	950 through 989

To conduct the Address Response Performance Test, perform the following procedure:

1. Switch OFF power to the Front End.

2. Disconnect the ac line power cord and all other high voltage inputs.

3. Ensure that the external trigger jumper (W1) on the Fast A/D Converter is positioned for normal measurement inputs on channels 0 and 20. Refer to Figure 165-2 in Section 3B of this manual.

4. Set the Fast A/D Converter address switch to "00", and install the Fast A/D Converter in the Front End bottom option slot.

5. Remove all other installed options to eliminate addressing conflict.

6. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the -165 Fast A/D Converter.

7. Reconnect power to the Front End and switch power ON.

8. Connect the calibrator output to the input connector test leads.

9. Set the calibrator output to 7.9000V dc.

10. Using a terminal or a computer emulating a terminal, send the following commands to the Front End.

    ```
    MODE=TERM  <CR>
    DEF CHAN(0)=DVIN,MAX=7.9  <CR>
    FORMAT=DECIMAL  <CR>
    SEND CHAN(0)  <CR>
    ```

    The value returned for the selected channel should be approximately 7.9V.

11. Switch Front End power OFF.

12. Using a common screwdriver, set the address switch on the Fast A/D Converter to "10". Switch power to the Front End ON.

13. Program the Front End to take a measurement on channel 100 by substituting channel "100" for "00" in both the DEF CHAN and SEND CHAN commands of step 10.

14. Repeat steps 11 through 13 for channel 200 (address set to 20), 400 (address set to 40), 600 (address set to 60), and 950 (address set to 95). The measurement on each channel should be approximately 7.9V. This procedures verifies proper operation under most addressing situations.

15. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -165 Fast A/D Converter.

Accuracy Verification Test

All voltage readings taken by the Front End depend on the accuracy of the Fast A/D Converter. The Accuracy Verification Test checks the Fast A/D Converter to see if its voltage measurement accuracy is within specifications.

To conduct the Accuracy Verification Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the Fast A/D Converter address switch to "00" and install the Fast A/D Converter in the top option slot of the Front End.

3. Connect test leads to the HI and LO terminals for channel 0 on either the -176 Voltage Input Connector or the -175 Isothermal Input Connector. Install the connector on the Fast A/D Converter.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

6. Set the calibrator output to 6.2000V (62 mV out of the divider).

7. Using a terminal or a computer emulating a terminal, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(0)=DVIN, MAX=0.062 <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0) <CR>
```

The returned value for channel 0 should be 62 mV +/- 0.044 mV.

8. Change to the 512 mV voltage range by redefining channel 0.

   To do this in the Terminal Mode, send the following command:

```
DEF CHAN(0)=DVIN, MAX=0.5 <CR>
```

9. Set the calibrator to 0. Remove the 100:1 divider and connect the calibrator output directly to the connector test leads on channel 0.

10. Set the calibrator to output 500 mV.

11. Request a measurement and verify that channel 0 returns a value of 500 mV +/- 0.25 mV.

    In Terminal Mode, take the measurement by sending the following command:

    SEND CHAN(0) <CR>

12. Change to the 8V range by redefining channel 0. Send the following command:

    DEF CHAN(0)=DVIN, MAX=7.9

13. Set the calibrator output to 7.9000V.

14. Request another measurement as in step 11.

    Verify that the returned value is within 7.9V +/- 0.004V.

15. Change to the 10V range by redefining channel 0. Send the following command:

    DEF CHAN(0)=DVIN, MAX=9 <CR>

16. Set the calibrator output to 9.000V.

17. Request another channel 0 measurement.

    The returned value should be 9V +/- 0.005V.

18. The Accuracy Verification Test is now complete.

Continue with the Overrange Indication Test if you are conducting a complete performance test of the -165 Fast A/D Converter.

Overrange Indication Test

The Overrange Indication Test determines if the Fast A/D Converter can detect and communicate a channel overrange condition to the mainframe controller.

To conduct the Overrange Indication Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the Fast A/D Converter address switch to "0" and install the Fast A/D Converter in the top option slot of the Front End.

3. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the -165 Fast A/D Converter.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the calibrator output to the input of the 100:1 divider.

   Connect the divider output to the input connector test leads.

6. Set the calibrator output to 6.8V (68 mV out of the divider).

7. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   MODE=TERM <CR>
   DEF CHAN(0)=DVIN,MAX=0.062 <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0) <CR>

   The value displayed for channel 0 should be 9.99999E+37.

8. Send the following command to inspect the fault condition:

   LIST ERROR <CR>

   The following error message should be displayed:

   Chan(0)-Out of range

9. The Overrange Test is complete.

Continue with the Open Thermocouple Response Test if you are conducting a complete performance test of the -165 Fast A/D Converter and you have not already performed the test in the Thermocouple/DC Volt Scanner performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test determines if the Fast A/D Converter can detect and communicate an open thermocouple condition on a channel to the mainframe controller.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the Fast A/D Converter address switch to "0" and install the Fast A/D Converter in the top option slot of the Front End.

3. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the -165 Fast A/D Converter.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test leads from the Isothermal Input Connector to a 1-kilohm resistor.

6. Using a terminal or a computer emulating a terminal, send the following commands to the Front End.

   ```
   MODE=TERM <CR>
   DEF CHAN(0)=TC,TYPE=JNBS <CR>
   FORMAT=DECIMAL <CR>
   TUNIT=CELSIUS <CR>
   SEND CHAN(0) <CR>
   ```

   The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

7. Replace the 1-kilohm resistor with a 3-kilohm resistor to simulate a high resistance or open thermocouple.

8. Request a measurement and verify that the returned value is:

   9.99999E+37

9. Send the following command to inspect the fault condition:

   LIST ERROR <CR>

   The following error message should be displayed:

   chan(0)-open tc

10. Disconnect the 3-kilohm resistor and the test leads from the Isothermal Input Connector.

11. Performance testing of the -165 Fast A/D Converter is complete.

COUNTER/TOTALIZER (-167)

Counter/Totalizer assembly is operating properly. These tests, listed below, can be performed individually, for a partial performance evaluation, or in sequence for a complete test:

- Address Response Test
- Reference Voltage Test
- Deadband Adjustment Test
- Frequency Test
- Event Counting Test

Accessing Counter/Totalizer Switches

To perform these tests, it is necessary to set switches on the Counter/Totalizer that are not accessible through the rear panel. These switches can be made accessible in three ways:

ALTERNATIVE 1

Install a Calibration/Extender Fixture (Fluke P/N 648741) in a Front End option slot, and install the Counter/Totalizer assembly on the fixture. Ensure that the switch on the fixture is set to EXTEND position.

With this method, the switches on the Counter/Totalizer assembly are accessible at all times.

ALTERNATIVE 2

If a Calibration/Extender Fixture is not available, remove all other option assemblies from the Front End and install the Counter/Totalizer assembly in the bottom slot. In this configuration, the switches can be reached without using an extender.

ALTERNATIVE 3

If neither of the previous alternatives is feasible, disconnect power and slide the Counter/Totalizer assembly out of the Front End to reach the switches. Reinstall the assembly and reconnect power to continue testing.

NOTE

The Counter/Totalizer's operating program resides in an EPROM. This EPROM may be either a 2716 installed in U57 or a 2732 installed in U49. Ensure that switch S2-1 is set to the position appropriate for the EPROM installed at the factory.

The locations of Counter/Totalizer switches and adjustments are shown in Figure 2A-6.

Address Response Test

The Address Response Test verifies that the Counter/Totalizer channel decade is selectable. To conduct the Address Response Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all other installed options to eliminate addressing conflict.

3. Note the setting of the function switches on the Counter/Totalizer assembly. Install the assembly in the Front End.

4. Set the Counter/Totalizer channel decade switches to position 00.

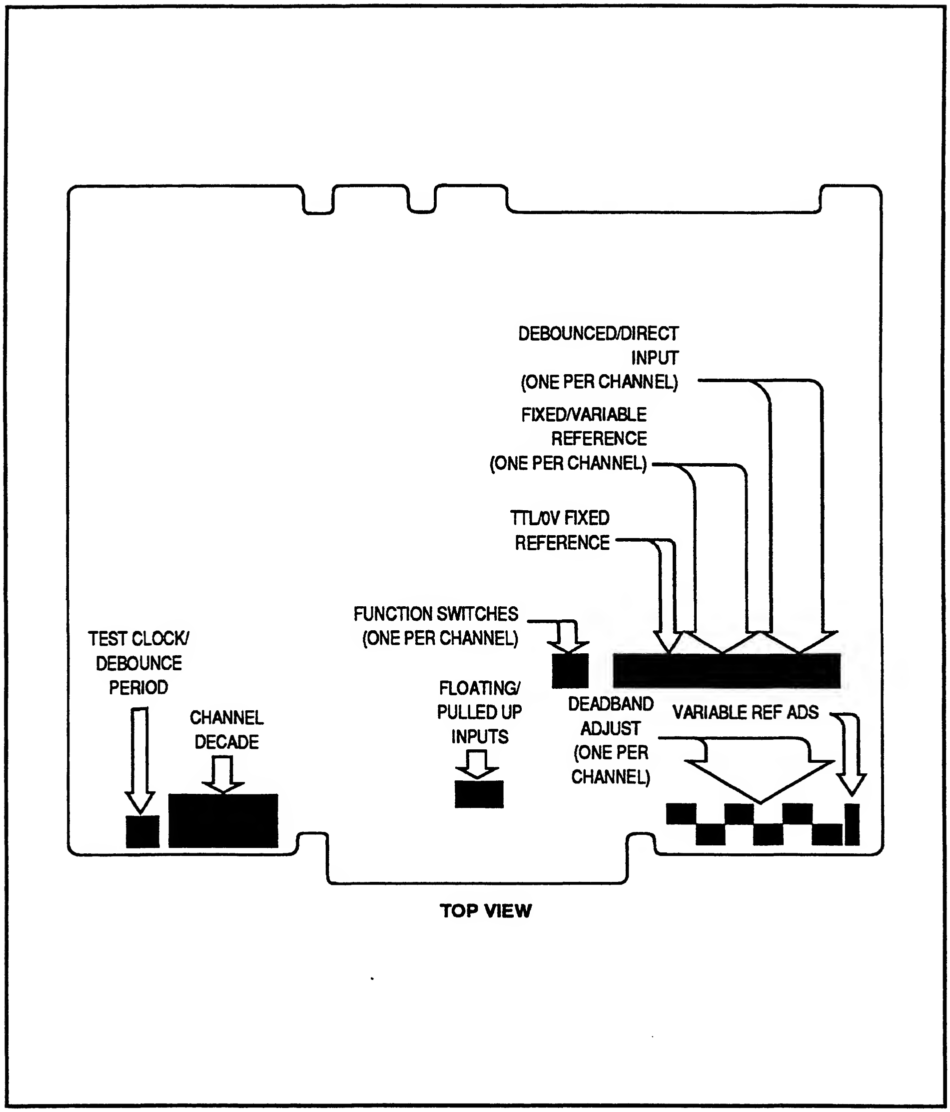


Figure 2A-6. Counter/Totalizer Switches and Adjustments

5. Reconnect the ac line cord to the Front End, and switch the power ON.

6. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   RESET CHAN(0..5) <CR>
   LIST CHAN(0..5) <CR>
   ```

   Verify that a listing for all designated channels is returned. The response should be either of the following:

   ctchan(channel number)=total

   ctchan(channel number)=freq

   The type function, (TOTAL or FREQ) should agree with the setting of the function switch for the specified pair of channels.

7. Switch OFF power to the Front End. Set channel decade switches on the the Counter/Totalizer to 01. Then switch power ON.

8. Program the Front End to list its hardware configuration for channels 10 through 15. To do this, substitute channels 10 through 15 for channels 0 through 5 in both the RESET CHAN and LIST CHAN commands of step 6.

9. Repeat steps 7 and 8 for switch settings 02 (channels 20 through 25), 04 (channels 40 through 45), 08 (channels 80 through 85), 10 (channel 100 through 105), 20 (channels 200 through 205), 40 (channels 400 through 405) and 80 (channels 800 through 805).

10. This completes the Address Response Test.

Reference Voltage Test

This Reference Voltage Test verifies that the 0V and TTL fixed reference voltages are within tolerance, that the variable reference is fully adjustable, and that both the fixed and variable reference voltages can be selected for each channel.

To conduct the Reference Voltage Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. To avoid addressing conflict, remove all other installed options.

3. Install the Counter/Totalizer assembly in the Front End.

4. Reconnect the ac line cord to the Front End, and switch the power ON.

5. Connect digital multimeter (DMM) test leads to the variable reference terminal and to one of the return terminals on the Counter/Totalizer input connector.

6. Using a small screwdriver, turn the variable reference adjustment screw counterclockwise until the DMM displays negative 10.00V +/- 0.10V. Then turn the screw clockwise until the DMM displays positive 10.00 +/- 0.10V.

7. Turn the deadband adjustment screw for each channel counterclockwise until it stops. Move the fixed/variable reference switch for each channel to the VARIABLE REFERENCE position.

8. By connecting the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, verify that the threshold voltage for each channel is between 9.80 and 10.20V.

9. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the 0V/TTL fixed reference switch to the 0V position.

10. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -0.10V and 0.10V.

11. Move the 0V/TTL fixed reference switch to the TTL position.

12. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between 1.30 and 1.50V.

13. This completes the Reference Voltage Test.

Deadband Adjustment Test

The Deadband Adjustment Test verifies that the deadband is fully adjustable for each channel.

To conduct the Deadband Adjustment Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. To avoid addressing conflicts, remove all other installed options.

3. Install the Counter/Totalizer assembly in the Front End.

4. Reconnect the ac line cord to the Front End. Switch the power ON.

5. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

6. Using a small screwdriver, move the test clock switch to position 0 (+14V output).

7. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the 0V/TTL fixed reference switch to the 0V position.

8. Using a small screwdriver, turn the deadband adjustment screw for each channel counter-clockwise until it stops.

9. Connect the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, and verify that the threshold voltage for each channel is between -0.04V and 0.04V.

10. For each channel, turn the deadband adjustment clockwise until it stops.

11. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -1.20V and -1.80V.

12. This completes the Deadband Adjustment Test.

Frequency Test

The Frequency Test checks the frequency measurement function for each channel. Measurement accuracy and underrange detection are tested.

To conduct the Frequency Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. To avoid addressing conflicts, remove all other installed options.

3. Move all of the function switches on the Counter/Totalizer assembly to the FREQ position. Move all of the debounced/direct input switches to the DIRECT INPUT position. Install the assembly in the Front End.

4. Set the channel decade switches to 00.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Using a small screwdriver, move the test clock switch to position 2 (100 KHz).

7. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

8. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0..5)=FREQ <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0..5) <CR>
   ```

   The returned channel readings should be 1.00000E+05 Hz (100 kHz) within a tolerance of 10 Hz.

9. Move the test clock switch to position 1 (-15 VDC output) and take another measurement from channels 0 through 5. Enter:

   ```
   SEND CHAN(0..5) <CR>
   ```

   Verify that 9.999999E+37 (a fault indication reading) is returned for each channel.

10. Send the following command to inspect the fault condition:

    ```
    LIST ERROR  <CR>
    ```

    The error displayed for the selected channels should show:

    Out of range

11. This completes the Frequency Test.

Event Counting Test

The Event Counting Test checks the event counting function for each channel. Measurement accuracy and overrange detection are tested.

To conduct the Event Counting Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. To avoid addressing conflict, remove all other installed options.

3. Move all of the function switches on the Counter/Totalizer assembly to the COUNT position.

4. Move all of the debounced/direct input switches to the DIRECT INPUT position.

5. Install the Counter/Totalizer in the Front End. Be sure that the channel decade switches are set to "00".

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Using a small screwdriver, move the test clock switch to position 3 (50 Hz W/BOUNCE).

8. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   DEF CHAN(0..5)=TOTAL <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0..5) <CR>
   ```

   Ignore the initial measurement response. As close as possible to 20 seconds after the first SEND CHAN command is executed, send another

   ```
   SEND CHAN(0..5) <CR>
   ```

A count of approximately 9000 (9.00000E+03) +/- 100 should be returned.

NOTE

The second SEND CHAN command returns the count accumulated since the first SEND CHAN command. Each additional SEND CHAN command returns only the counts since the previous SEND CHAN command. Timing is critical in performance of this test.

9. Move all of the debounced/direct input switches to the DEBOUNCED INPUT position. Repeat step 8 to take more measurements.

   Ignore the first set of readings. Each additional measurement should respond with a count of 1000 (1.00000E+03) +/- 25 on channels 0 through 5.

10. This completes the Event Counting Test.

DIGITAL I/O ASSEMBLY (-168)

Three performance tests are used to verify that the Digital I/O Assembly is operating properly. These are:

- Address Response Test

  This test determines if the Front End mainframe controller can communicate with the Digital I/O Assembly. To exercise all address lines, the Digital I/O Assembly address switch is set to a variety of positions.

- Output Performance Test

  This test uses the -169 Status Output Connector to verify operation of the Digital I/O Assembly output capability.

- Input Performance Test

  This test uses the -179 Digital/Status Input Connector to verify operation of the Digital I/O Assembly input capability.

To perform these tests, it is necessary to gain access to the terminals of the connector being used. The two access methods are described in the following paragraphs.

Install a Calibration/Extender Fixture (Fluke P/N 648741) in one of the Front End option slots and install the Digital I/O Assembly and the connector on the fixture. Be sure the switch on the fixture is set to the EXTEND position. Using this method, the connector's terminals are accessible at all times.

If a Calibration/Extender Fixture is not available, remove all other options from the Front End and install the Digital I/O Assembly in the bottom slot. Remove the connector's cover and install the connector on the Digital I/O Assembly. In this configuration, the terminals can be reached without using an extender.

Address Response Test

Use the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the Digital I/O Assembly address switch to "00", and install the Digital I/O in a Front End option slot.

3. To avoid addressing conflict, remove all other installed options.

4. Reconnect the ac line power cord to the Front End. Then switch power ON.

5. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   ```
   MODE=TERM <CR>
   RESET CHAN(0..19) <CR>
   LIST CHAN(0..19) <CR>
   ```

   Verify that a listing for all designated channels is returned. The response should be:

   dgchan(channel number) = statout

6. Switch OFF power to the Front End. Set the address switches on the Digital I/O Assembly to 01. Now switch power ON.

7. Program the Front End to list the hardware configuration for channels 10 through 29. Do this by substituting (10..29) for (0..19) in the RESET CHAN and LIST CHAN commands in step 5.

8. Repeat steps 6 and 7 for each of the following address switch settings:

   02 (channels 20 through 39)
   04 (channels 40 through 59)
   08 (channels 80 through 99)
   10 (channels 100 through 119)
   20 (channels 200 through 219)
   40 (channels 400 through 419)
   80 (channels 800 through 819).

9. This completes the Channel Selection Test.

Output Test

To conduct the Output Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot of the Front End. Set the fixture switch to the EXTEND position.

3. To avoid addressing conflict, remove all other installed options.

4. Set the Digital I/O channel decade switches to 00, then install the Digital I/O Assembly on the Calibration/Extender Fixture.

5. Install the -169 Status Output Connector on the Digital I/O Assembly.

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Testing the output drive capability of each channel requires an external voltage source, a current limiting/pull-up resistor, and a DMM, interconnected as shown in Figure 2A-7 and described below:

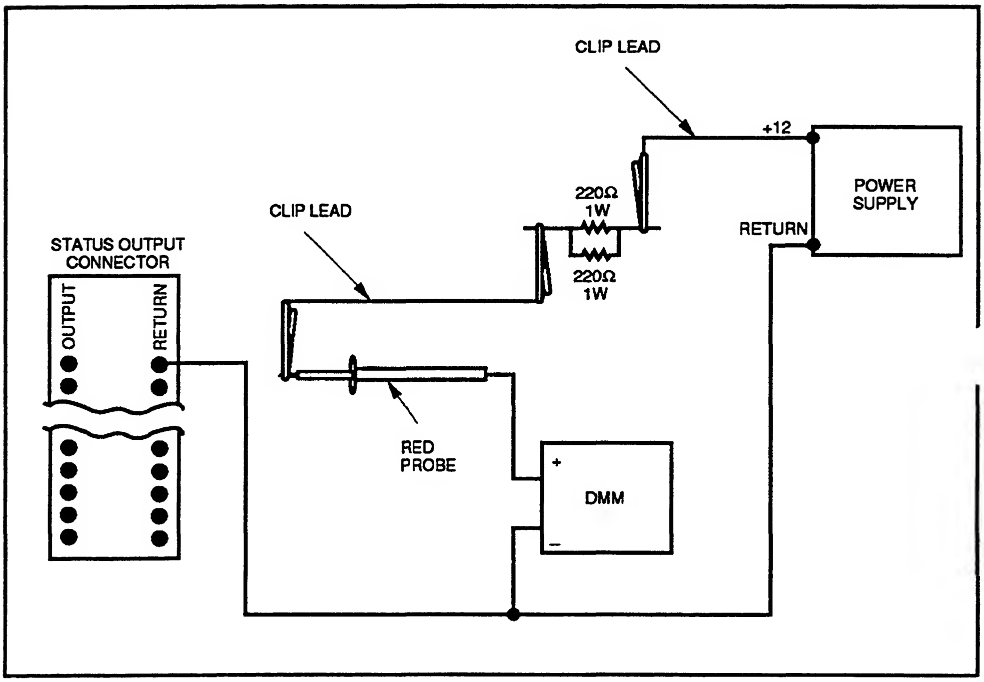


Figure 2A-7. Interconnecting Output Test Equipment

a. Using clip leads, connect a +12V lab type power supply to one side of two 220 ohm, 1W carbon resistors wired in parallel.

b. Connect the power supply RETURN (-) terminal to the RETURN terminal of the -169 Status Output Connector.

c. Using clip leads, connect the other side of the resistor to the probe of the DMM's volt/ohm input (red) test lead.

d. Connect the DMM's common lead (black) to RETURN on the Status Output connector.

e. Set the DMM to measure a full scale voltage of +12V, turn the power supply ON, and ensure that the DMM reads approximately 12V.

8. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

```
MODE=TERM <CR>
DEF CHAN(0..19)=STATOUT <CR>
CHAN(0..19)=0 <CR>
```

a. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector. The DMM should continue to read +12V, indicating that the status output for channel 0 HAS NOT been turned ON.

b. Repeat step a for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

c. Send the following command to the Front End:

```
CHAN(0..19)=1 <CR>
```

d. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector. The DMM should read 1V or less, indicating that the status output for that channel HAS been turned ON, and that it is able to sink a minimum of 100 mA.

e. Repeat step d. for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

8. This completes the Output Test for the Digital I/O Assembly.

Input Test

To conduct the Input Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot of the Front End. Set the fixture switch to the EXTEND position.

3. To avoid addressing conflict, remove all other installed options.

4. Set the Digital I/O channel decade switches to 00, then install the Digital I/O Assembly on the Calibration/Extender Fixture.

5. Using a small jumper wire, short SIGNAL to RETURN on terminal 21 of the Digital/Status Input Connector.

   Remove all other connections. Install the input connector on the Digital I/O Assembly.

6. Reconnect ac line power to the Front End and switch the power ON.

7. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

   MODE=TERM <CR>
   DEF CHAN(0..19)=STATIN <CR>
   FORMAT=DECIMAL <CR>
   SEND CHAN(0..19) <CR>

   a. Verify status input responses. Because all status channel inputs (0..19) are open, the measurement should be returned as a 1 (1.00000E+00).

   b. Short the SIGNAL to RETURN terminals for channel inputs 0 through 19.

   c. To take new readings, send the Front End the following command:

      SEND CHAN(0..19) <CR>

   d. The returned readings for all 20 channels should be 0 (0.00000E+00).

8. This completes the Digital I/O Assembly Input Test.

STATUS OUTPUT CONNECTOR (-169)

There is no separate performance test for the -169 Status Output Connector. The connector is tested during the output mode performance test for the -168 Digital I/O Assembly.

ANALOG OUTPUT ASSEMBLY (-170)

Two performance tests are required to verify that the Analog Output Assembly operates properly and meets its accuracy specifications. These tests are:

- Address Response Test
- Accuracy Verification Test

Address Response Test

The Address Response Test verifies that the mainframe controller assembly can communicate properly with the Analog Output. All address switch signals are tested.

To conduct the Address Response Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. To eliminate addressing conflict, remove all other installed options.

3. Set the channel decade switches of the Analog Output Assembly to 00, and install the assembly in the uppermost option slot of the Front End.

4. Reconnect the ac line cord and switch Front End power ON.

5. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

```
MODE=TERM <CR>
RESET CHAN(0..3) <CR>
LIST CHAN(0..3) <CR>
```

A channel definition listing in the following form should be returned for each of four channels (0 through 3).

aochan(channel number)=unipolv

where "(channel number)" indicates the number of the channel definition listed.

6. Switch power OFF to the Front End. Set the analog output channel decade switches to position 01. Then switch power ON.

7. Program the Front End to list its hardware configuration for channels 10 through 13 by substituting channels 10 through 13 for channels 0 through 3 in both the RESET CHAN and LIST CHAN statements of step 5.

8. Repeat steps 6 and 7 for the following address switch settings:

02	(channels 20 through 23)
04	(channels 40 through 43)
08	(channels 80 through 83)
10	(channels 100 through 103)
20	(channels 200 through 203)
40	(channels 400 through 403)
80	(channels 800 through 803)

9. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -170 Analog Output Assembly.

Accuracy Verification Test

The Accuracy Verification Test ensures that all analog outputs from the assembly are within specifications.

If the -170 Analog Output Assembly fails the Accuracy Verification Test, calibration is normally required. Refer to the Helios Plus Service Manual for calibration procedures.

To conduct the Accuracy Verification Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the channel decade switches of the Analog Output Assembly to 00, and install the assembly in the uppermost option slot of the Front End.

3. To avoid addressing conflict, remove all other installed options.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Allow the Front End a warm-up period of about 30 minutes before proceeding.

6. Using a digital multimeter (DMM), verify that the outputs of the Analog Output are within tolerance of their zero percent output values as given in Table 2A-5.

CAUTION

The exposed screws on top of the Analog Output connector block can be probed only if they are screwed down tightly. Otherwise, contact is not made with the output from the -170 Assembly.

Table 2A-5. Values and Tolerances for Zero Percent Outputs

OUTPUT SIGNAL	OUTPUT VALUE	TOLERANCE	TERMINAL PAIR PER CHANNEL 0+	0-	1+	1-	2+	2-	3+	3-
0 - 10V	0.000V	+/-0.010V	1	2	6	7	11	12	16	17
-5 - +5V	-4.997V	+/-0.010V	1	3	6	8	11	13	16	18
4 - 20 mA	4.000mA	+/-0.020mA	4	5	9	10	14	15	19	20

7. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

```
MODE=TERM <CR>
DEF CHAN(0..3)=UNIPOLV <CR>
FORMAT=DECIMAL <CR>
CHAN(0..3)=10 <CR>
```

   a. Using a DMM, verify that the outputs of the Analog Output are within tolerance of their full scale output values as given below:

OUTPUT VALUE AND TOLERANCE FOR UNIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
9.997V	+/- 0.010V	1	2	6	7	11	12	16	17

   b. Program the Front End to provide a full scale bipolar voltage source of +5V by sending the following commands:

```
DEF CHAN(0..3)=BIPOLV  <CR>
CHAN(0..3)=5  <CR>
```

c. Using a DMM, verify that the bipolar voltage outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR BIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
4.997V	+/- 0.010V	1	3	6	8	11	13	16	18

d. To provide a full scale direct current output of 20 milliamps send the Front End the following commands:

```
DEF CHAN(0..3)=DCOUT <CR>
CHAN(0..3)=0.02 <CR>
```

e. Use a DMM to verify that the direct current outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR DC CURRENT FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
19.996mA	+/- 0.020mA	4	5	9	10	14	15	19	20

8. The Accuracy Verification Test for the Analog Output Assembly is complete.

If the -170 Analog Output Assembly fails the Accuracy Verification Test, it should be calibrated.

CURRENT INPUT CONNECTOR (-171)

The following test verifies that the -171 Current Input Connector is fully operational. This procedure can be used as an initial acceptance test or as a troubleshooting aid.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the -161 A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below the -161 A/D Converter.

3. Avoid addressing conflict by removing all other addressable options from the Front End.

4. Connect test leads to the HI and LO terminals for channel 0 on the Current Input Connector. Install the Current Input Connector on the Thermocouple/DC Volts Scanner.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Using the Fluke 5100B as a direct current source, connect the test leads as follows:

From: Input Connector Test Lead		To: Current Source
HI	------------	HI
LO	------------	LO

7. Set the current source output to 63.000 mA dc.

8. Using a terminal or a computer emulating a terminal, send the following commands to the Front End:

```
MODE=TERM <CR>
DEF CHAN(0..19)=DCIN <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0) <CR>
```

   Verify that the value returned for the selected channel is between 6.28000E-02 and 6.32000E-02 (63 +/- 0.2 mA).

9. Set the current source output to 0. Move the test leads of the Current Input Connector to the terminals for the next channel to be tested.

10. Repeat steps 7 through 9 for each remaining current input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command.

11. Performance testing of the Current Input Connector is complete.

TRANSDUCER EXCITATION CONNECTOR (-174)

There is no separate performance test for the Transducer Excitation Connector. The connector is tested during the performance testing of the Transducer Excitation Module.

ISOTHERMAL INPUT CONNECTOR (-175)

The following performance test can be used to verify that the Isothermal Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

The performance test is divided into two parts: a Channel Integrity Test, which verifies that all channels on the connector are functional; and an Accuracy Verification Test, which verifies that the connector channels meet accuracy specifications. Each test may be performed independently. However, both parts must be performed to test the Isothermal Input Connector fully.

These tests can be performed using either one of two types of a/d converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

Channel Integrity Test

To conduct the Channel Integrity Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate a/d converter to 00.

3. To avoid addressing conflict, remove all other installed options.

4. Connect a shorting wire between HI and LO terminals for channel 0 on the Isothermal Input Connector.

   Remove connections to all other isothermal connector terminals.

5. Now, referring to the a/d converter-specific instructions below, install the -175 Isothermal Input Connector:

   o -161 High Performance A/D Converter

      a. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the a/d converter.

      b. Install the -175 connector onto this -162 scanner.

   o -165 Fast A/D Converter

      a. Install the -175 connector directly onto this a/d converter.

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Using a terminal or a computer emulating a terminal as the selected host, send the following commands to the Front End.

   ```
   MODE=TERM <CR>
   DEF CHAN(0..19)=TC,TYPE=JNBS <CR>
   FORMAT=DECIMAL <CR>
   TUNIT=CELSIUS <CR>
   SEND CHAN(0) <CR>
   ```

   The value returned for the selected shorted channel should be approximately the ambient temperature.

8. Remove the shorting wire and reconnect it to the terminals for the next channel to be tested.

9. Repeat steps 7 and 8 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command.

10. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the Isothermal Input Connector and you have not already performed the test on either the A/D Converter or the Thermocouple/DC Volts Scanner.

Accuracy Verification Test

To conduct the Accuracy Verification test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate a/d converter to 00.

3. To avoid addressing conflict, remove all other installed options.

4. If a -161 a/d converter is being used, install a -162 Thermocouple/DC Volts scanner in the slot directly below the a/d converter.

5. Connect a JNBS thermocouple to the HI and LO terminals for channel 11 on the Isothermal Input Connector.

6. Install the connector onto either the -162 Thermocouple/DC Volts Scanner or the Fast A/D Converter.

NOTE

If other than a J type thermocouple is used, be sure that the TYPE parameter of the DEF CHAN command is consistent with the type of thermocouple being used.

7. Reconnect the ac line cord to the Front End and switch the power ON.

8. Insert the thermocouple and a mercury thermometer in a room temperature bath, and allow 20 minutes for thermal stabilization.

9. Using a terminal or a computer emulating a terminal as the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(11)=TC,TYPE=JNBS <CR>
FORMAT=DECIMAL <CR>
TUNIT=CELSIUS <CR>
SEND CHAN(11) <CR>
```

The value displayed for channel 11 should be the temperature of the room temperature bath (within the tolerances in Table 2A-6) as measured by the mercury thermometer.

Table 2A-6. Thermocouple Accuracy Specifications

THERMOCOUPLE TYPE	90 DAYS @ 15-35 DEGREES C		1 YEAR @ 15-35 DEGREES C	
	-161 A/D	-165 A/D	-161 A/D	-165 A/D
JNBS	.35	.95	.4	1.0
KNBS	.4	1.2	.45	1.35
TNBS	.6	1.3	.65	1.35
ENBS	.3	.9	.35	.95
JDIN	.4	.9	.45	1.0
TDIN	.5	1.05	.55	1.1
NNBS	.6	1.7	.7	1.75

10. The Accuracy Verification Test is complete.

VOLTAGE INPUT CONNECTOR (-176)

The following performance test can be used to verify that the Voltage Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

These tests can be performed using either one of two types of a/d converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate a/d converter to 00.

3. To avoid addressing conflict, remove all other installed options.

4. Connect test leads to the HI and LO terminals for channel 0 on the -176 Voltage Input Connector.

5. Now, referring to the a/d converter-specific instructions below, install the -176 Voltage Input Connector:

   o -161 High Performance A/D Converter

      a. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the a/d converter.

      b. Install the -176 connector onto this -162 scanner.

   o -165 Fast A/D Converter

      a. Install the -176 connector directly onto this a/d converter.

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Connect the dc voltage calibrator output to the input of the 100:1 divider. Connect the divider output to the Voltage Input Connector test leads.

8. Set the calibrator output to 6.3000V dc (63 mV from the divider).

9. Using a terminal or a computer emulating a terminal as the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(0..19)=DVIN,MAX=0.063 <CR>
FORMAT=DECIMAL <CR>
SEND CHAN(0) <CR>
```

Depending on the a/d converter in use, verify the returned value for the selected channel. Look for the following value ranges:

- o -161 High Performance A/D Converter

  6.29800E-02 through 6.30200E-02 (63$\pm$0.02 mV)

- o -165 Fast A/D Converter

  6.29500E-02 through 6.30500E-02 (63$\pm$0.05 mV)

10. Set the calibrator output to 0. Then move the test leads of the Voltage Input Connector test to the terminals for the next channel to be tested.

11. Repeat steps 8 through 10 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

12. The Voltage Input Connector performance test is now complete.

RTD/RESISTANCE INPUT CONNECTOR (-177)

There is no separate performance test procedure for the -177 RTD/Resistance Input Connector. The -177 connector is tested along with the -163 RTD/Resistance Scanner.

DIGITAL/STATUS INPUT CONNECTOR (-179)

There is no separate performance test for the -179 Digital/Status Input Connector. The -179 connector is tested during input mode performance testing for the -168 Digital I/O Assembly.

Section 3
Installation and Setup

CONTENTS

3B: OPTIONS AND ACCESSORIES

3C: INSTALLATION VERIFICATION

INTRODUCTION

This section of the manual is divided into three main parts:

SECTION 3A explains how to set up a measurement system using the Fluke Helios Plus Data Acquisition Front End. It explains how to prepare the mainframe for installation. Directions on how to configure some of the more popular models of computers are given in an Appendix. Even if your computer is not included in the setup instructions in the appendix of this manual, the guidelines there may help you locate the necessary information in the literature that accompanied your computer at the time it was purchased.

Read this section before attempting to install or operate the Front End. Refer to Section 1 for unpacking instructions and other preliminary information needed before you turn on the instrument. Refer to Section 3B for specific instructions on setting up the various options. If any difficulties arise during installation or operation, contact your nearest Fluke Service Representative.

SECTION 3B explains how to set up each of the many options available for the Front End. For each option, this section provides a short description of function and capability, a photograph to aid in identification, a few words explaining where to find measurement and applications information, followed by setup, installation, and programming information.

SECTION 3C contains tests to verify correct operation of the Front End after it has been installed.

SECTION 3A - THE MAINFRAME

This first part of Section 3 contains instructions for setting up the mainframe, including voltage selection and setting the internal communications switches.

PLACEMENT

After unpacking and inspecting the Front End, select a location for installation. Case dimensions are shown in Figure 3-1. The self-contained case may be placed in any convenient location, but provide adequate clearance for rear-panel cabling and ventilation.

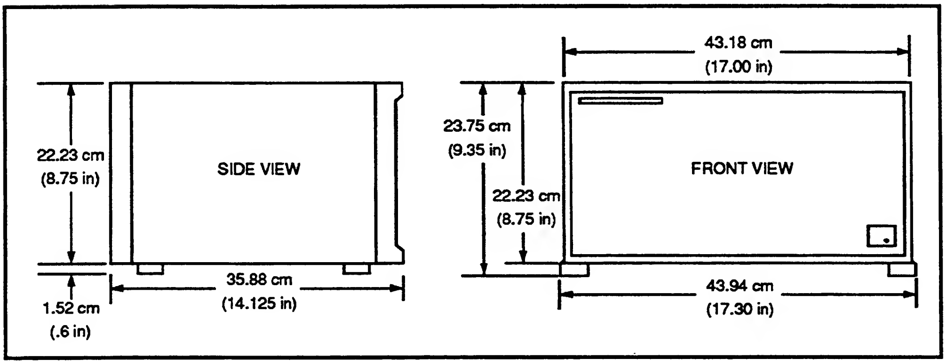


Figure 3-1. Case Dimensions

RACK MOUNTING

Two accessories are available to aid in mounting the Front End.

- o Rack Mount Kit (Y2045)

  The Y2045 Rack Mount Kit facilitates the placement of a front end into a standard 19-inch electronic equipment rack. The only tool required for installation is a medium-sized, Phillips screwdriver.

- o Rack Slide Kit (Y2044)

  The Y2044 Rack Slide Kit facilitates servicing a front end while it is installed in a standard 19-inch electronic equipment rack. The unit is secured in the equipment rack, yet may be pulled out along the slide for reconfiguring and servicing the system. The only tools required for installation are medium-sized, Phillips and flat-head screwdrivers.

Full installation instructions are provided with each kit and included in Section 3B of this manual.

CONFIGURING THE FRONT END

The next few pages describe how to change the electrical characteristics of the Front End to match local power and the computer to which it will be connected. You only need to change these settings if they don't agree with local line power or if the host computer cannot be set to match the Front End's default settings.

NOTE

Helios Plus reverts to 'Battery Power Lost' default values (as described in Section 9d) when power is interrupted during any of the following conditions:

- o During initial 12 seconds of operation (self-test routine execution).
- o During execution of any DEF command.
- o During execution of any RESET command.

Line Power Voltage Selection

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

Before connecting the power cord to the Front End and turning on the power, first see if the power supply has been set to the proper line voltage. A label on the back of the unit indicates the factory setting.

NOTE

Setting the line voltage may not be necessary on your unit. Some units use power supplies that automatically adjust to line power voltage. Check the rear panel to identify these units. If there is no specific line voltage marked by the input power connection, your unit uses an auto-switching power supply; no separate line voltage setting is necessary, and the following procedure need not be followed.

CAUTION

Incorrect voltage selection may damage the Computer Interface Module and void your warranty. If the voltage is not set for the correct operating voltage, the unit will either fail to operate, or will be severely damaged.

If it is necessary to change the line voltage, perform the following procedure with the power cord disconnected:

1. Remove the Computer Interface Module by removing the four #6-32 Phillips-head screws on the rear panel. See Figure 3-2 to locate the screws.

2. See Figure 3-3. Slide the Module out by grasping the finger indentation in the fan filter hole and slide it straight back and out.

3. Refer to Figure 3-4 to locate the Line Power Voltage Pins. To select 180 to 264V operation, connect the wire to the pin marked 220V. For 90 to 132V operation, place the wire on the pin labeled 110V.

4. While the unit is open, locate the 50/60 Hz line frequency selection switch on S3. Ensure that it is in the proper position to match the local line frequency. If it is not, change its position before continuing. For 50-Hz operation, place the switch in the 0 position (toward card cage). For 60-Hz operation, place it in the 1 position.

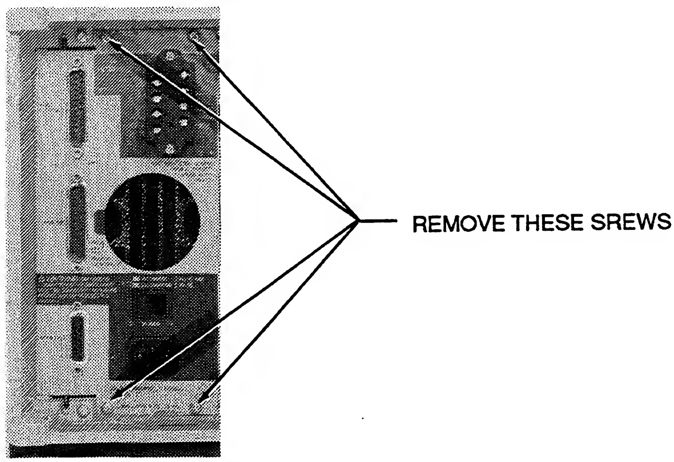


Figure 3-2. Computer I/F Module Securing Screws

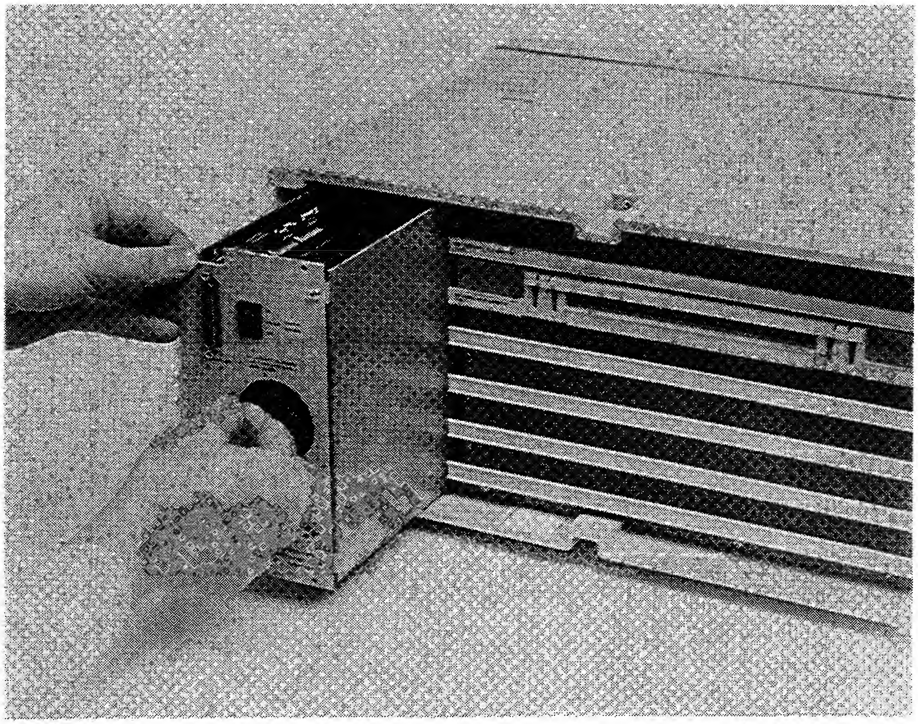


Figure 3-3. Removing the Computer Interface Module

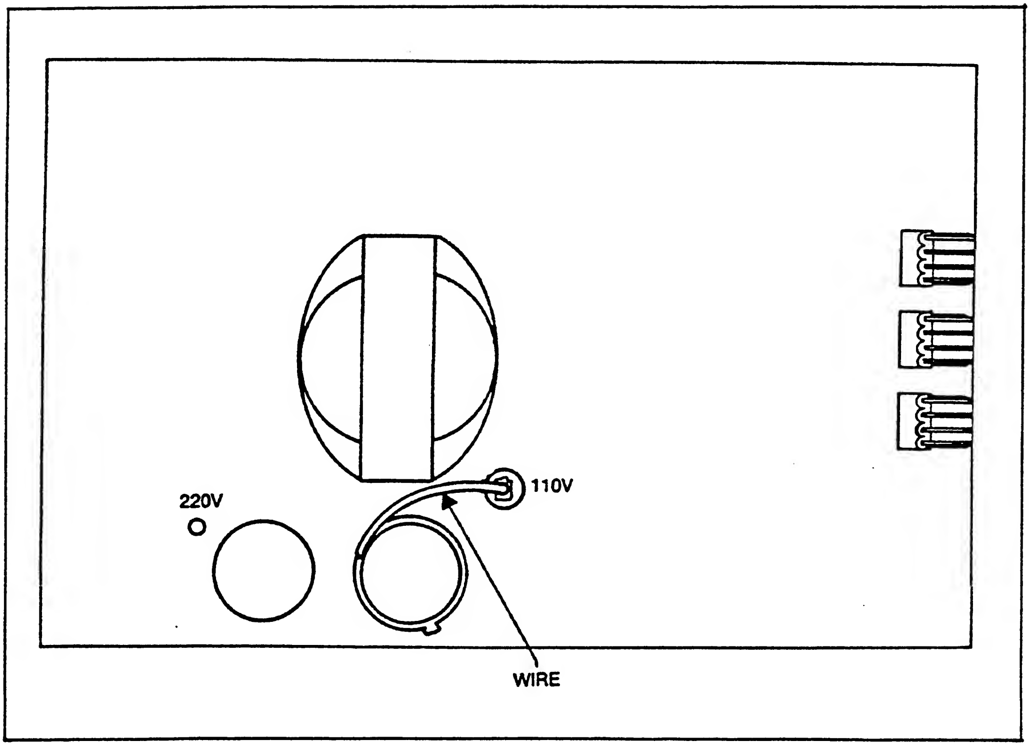


Figure 3-4. Line Power Voltage Pins

5. Properly mark the power setting on the outside of the unit after changing the line power voltage.

6. If no other settings need to be changed, slide the Computer Interface Module back into the Front End, and reinstall the Phillips-head screws. If you need to change any of the communication parameters, refer to the next section before reinstalling the Computer Interface Module.

Preparing to Connect to the Host Computer

The Front End can be controlled by any computer that has an RS-232-C port or an RS-422 port by using a variety of asynchronous bit-serial communication techniques. The two major categories are:

- Serial Interfacing Using Modems

  Using the RS-232-C interface with appropriate modems (devices that transmit and receive bit-serial data) connected to the telephone service, the Front End may be programmed and run from great distances. In a similar way, several Front Ends can be accessed by one host computer.

- Serial Interfacing Using Dedicated Lines

  Serial interfacing is also possible over runs of certain lengths without using modems. Using the RS-232-C interface, with a distance of less than 50 feet between the Front End and the host, a hard-wired direct connection can be made using a null-modem cable that duplicates the effect of two modems. Null-modem cables are available as Fluke Accessories Y1702, Y1703, or Y1705 . In systems with runs up to 4000 feet, hard-wired connections can be made in an RS-422 system using twisted-pair cable.

Configuration Summary

The Front End can be remotely accessed by a host computer in the following types of networks:

- RS-232-C direct-connect, two-point
- RS-232-C with modems over a dedicated line, two-point
- RS-232-C with auto-answer modems (switched serviced)
- RS-422 direct-connect, two-point
- RS-422 direct-connect, multipoint (up to ten Front Ends)

Where to Go From Here

To use the Front End in the way best suited to your application, it is important to understand the nature of serial data and how it is transferred. Appendix 9b provides an introduction to serial data, a description of the character format choices available, and an overview of the sequence of events that have to occur to accomplish data transfer. If you are experienced with serial communication, and know exactly how you want to configure the Front End and host computer, continue with this section. Persons who are unfamiliar with serial data communications may find a short detour to the Appendix to be of value.

Setting the Communication Switches

The Front End and the host computer must be configured so that the communication characteristics match. The table below shows the configuration of the Front End as it is shipped from the factory.

Table 3-1. Default Communication Parameters

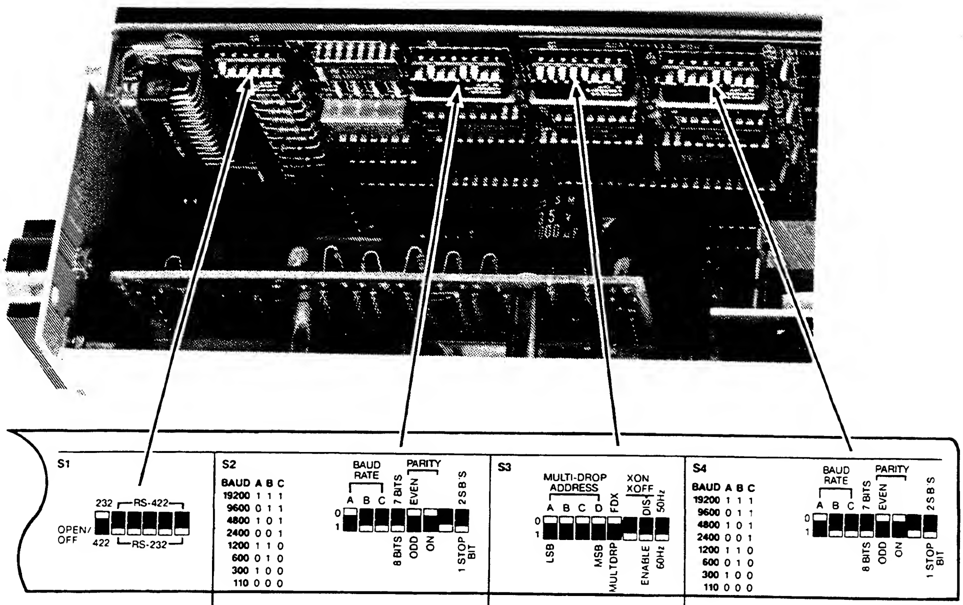
COMMUNICATIONS TYPE	RS-232-C
TRANSMISSION MODE	Full Duplex
BAUD RATE	9600
PARITY	OFF
NUMBER OF DATA BITS	8
NUMBER OF STOP BITS	1

If these settings match your chosen communication method, use the table to configure the host computer's communication parameters. If you don't know how to change these things on your computer, Appendix 9a has instructions for many major brands. If your computer is not included, be sure to consult the literature that came with it.

If these settings do not match your chosen communication method, you will have to change the settings of the Front End. To begin, refer to the "Line Power Voltage Selection" procedure in the previous section to remove the Computer Interface Module.

Figure 3-5 shows the location of the communication parameter selection switches. Tables within the Figure show the settings (except for the multidrop address) needed to configure the Front End for various kinds of operation.

HELIOS PLUS



Host Computer Port

Printer Port

WHITE = SELECTED

Figure 3-5. Communications Parameter Selection Switches

NOTE

The switches are shown in the position as shipped (white = switch position). The 50/60 Hz switch is set to the position required to match the line frequency used in the country to which the unit is shipped.

If you are using RS-422 and have selected multipoint mode, use Table 3-2 below to select the multipoint address 0 through 9 for the Front End you are configuring.

Table 3-2. Multipoint Addresses

Address	A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

CONNECTING TO THE HOST COMPUTER

The next several pages describe the interface in detail. This information is a technical description of the way that the RS-232 and RS-422 interface standards have been implemented on the Front End, and gives the connector pin assignments and signal descriptions.

The Dual Function Interface Connector

The Serial Data Interface is brought out to a 25-pin subminiature "D" connector that functions both for RS-232-C and for RS-422 communications. This connector is the uppermost one when the Computer Interface Module is installed in the Front End.

RS-232-C Signal Descriptions

The Front End is implemented as data terminal equipment (DTE) as described by Electronic Industries Association (EIA) standard RS-232-C. As a DTE unit, the Front End must be connected to data communication equipment (DCE). Modems and null-modem cables are examples of DCE.

Table 3-3 lists the RS-232-C signals used by the Front End, and their functions and pin assignments. The following section gives a brief description of each circuit. The signals are also specified by Comite Consultatif International Telegraphique et Telephonique (CCITT).

Table 3-3. RS-232-C Circuits Supported by the Host Computer Port

Pin Number	Circuit Name		Direction
1	AA	Protective Ground	(Chassis Ground)
2	BA	Transmitted Data	To modem
3	BB	Received Data	From modem
4	CA	Request to Send	To modem
5	CB	Clear to Send	From modem
6	CC	Data Set Ready	From modem
7	AB	Signal Ground	(Reference Ground)
8	CF	Received Line Signal Detect	From modem
9	(no connection)		
10	(no connection)		
11	(no connection)		
12	SCF	Secondary Received Line Signal Detect (not used)	
13	(no connection)		
14	(no connection)		
15	(no connection)		
16	(no connection)		
17	(no connection)		
18	(no connection)		
19	(no connection)		
20	CD	Data Terminal Ready	To modem
21	(no connection)		
22	CE	Ring Indicator	From modem
23	(no connection)		
24	(no connection)		
25	(no connection)		

NOTE

When an RS-232-C signal is high, its logic state is true, and its voltage level is more positive than plus three volts. When the signal is low, its logic state is false, and its voltage level is more negative than minus three volts.

The functions of RS-232-C signals used by the Front End are described below. The CCITT codes are included in parentheses:

- AA (101) - Protective Ground
  Protective Ground is the common chassis ground for the Serial Interface and modem, and is connected to earth ground through the power cord.

- AB (102) - Signal Ground
  Signal Ground is the common reference for all the following interface signals.

- BA (103) - Transmitted Data
  Transmitted Data carries the stream of data bits generated by the Front End to the modem.

- BB (104) - Received Data
  Received Data is the line that carries data received and demodulated by the modem to the Front End.

- CA (105) - Request to Send
  Request to Send activates the modem. When this signal is high, the modem starts sending a primary carrier and the Serial Interface is in the transmit mode. In full-duplex systems, CA is always high as long as the network is in a connected state and the equipment power is on.

- CB (106) - Clear to Send
  Clear to Send is set high by the modem when CA (Request to Send) is detected to be high. CB is set high to show that the modem is sending a carrier and is ready to send data. There is often a slight response delay from the time CA is sent to the time CB goes high.

- CC (107) - Data Set Ready
  Data Set Ready is set high when the modem is powered-on and ready for operation.

- CD (108.2) - Data Terminal Ready

  Data Terminal Ready is set high when the Front End is powered on and ready for operation. When an auto-answer modem is used, CD remains low until CE (Ring Indicator) is detected to be high. When CE is high, the Front End responds by setting CD high. When CD is high, the modem is taken off-hook to establish a telephone line connection, and when CD is set low, the modem hangs up the line. The connection may be ended when the host sets CD low, sends the character sequence, DLE EOT, or stops sending a carrier. Also, when the Front End detects CF (Received Line Signal Detect) to be low for more than 10 seconds, it sets CD low to disconnect the line.

- CE (125) - Ring Indicator
  Ring Indicator is constantly monitored by the Front End when it is in the auto-answer mode. When CE is detected to be high, the Serial Interface sets CD (Data Terminal Ready) high, to instruct the modem to answer the line, establishing a communication channel with the host.

- CF (109) - Received Line Signal Detect
  Received Line Signal Detect is set high by the modem whenever it detects a suitable primary carrier in the receive state. This lets the Front End know that the primary carrier is on.

- SCF (122) - Secondary Received Line Signal Detect
  Not used by Front End.

Data Channel Protocols

A variety of system configurations are possible in an RS-232-C system. The Front End can be connected directly to the host computer if the units are separated by a distance of 50 feet or less. If the Front End and the host are more than 50 feet apart, modems may be used to provide the communication medium.

Helios Plus always operates in full-duplex mode.

DIRECT CONNECTION

In a full-duplex, direct-connect system the Front End and host computer are both acting as DTE. Therefore, a Null-Modem Cable must be used to simulate the presence of two modems. The Null-Modem Cable connects CA (Request to Send) to CB (Clear to Send) thus allowing the Front End to transmit at any time, and routes the transmitted data to the receive channel at the other end. The Null-Modem Cable can be used alone or in conjunction with a standard RS-232 cable to connect the Front End to the host computer.

When the Front End is operated as part of a full-duplex direct-connect system, CA (Request to Send), SCA (Secondary Request to Send), and CD (Data Terminal Ready) are set high at power-up, to enable two-way communication.

COMMUNICATING USING MODEMS

The RS-232-C specifications allow up to 50 feet of cable in a direct connect system. For longer distances between the host and the Front End, full-duplex communication can be established using modems. Two of the most commonly used modems are the Bell Standard 103, which transmits at a bit rate of 300 baud, and the Bell Standard 212A, which transmits at a bit rate of 1200 baud.

Full-duplex modems connected to the Front End and the host can be linked by a dedicated wire or a telephone line. Using full-duplex, each modem transmits data on its own channel. Each channel has its own carrier frequency, allowing two-way data transfer to take place on the same line.

In full-duplex data communication over a telephone line, there is no distance limit, but there is a limit on speed. Two communication channels must fit within the typical three kilohertz bandwidth of a telephone line. Since a signal with a higher baud has a wider bandwidth, baud is limited. When two data channels share a line, the maximum bit rate is typically 1200 baud, depending on the type of modem. Check the modem specifications.

COMMUNICATING USING AUTO-ANSWER MODEMS

If the Front End is used with a full-duplex modem with auto-answer capability on the direct dial telephone network, the host computer can access the Front End from a remote location. The host computer can be connected to the direct dial network with an auto-dial modem (such as the Racal-Vadic VA212PA).

At power-up the Front End asserts signal CD (Data Terminal Ready) low if auto-answer mode has been selected and if the line is not ringing. The host computer may dial the number for the Front End at the remote site at any time. When it does, the Front End detects signal CE (Ring Indicator) high, and responds by asserting CD (Data Terminal Ready) high. This tells the auto-answer modem to answer the line and a connection is established. The modem, in turn, signals to the Front End that the line has been answered, and communication between the host and the Front End can begin.

Cable Configurations And Connections

To link the Front End to a host computer using the RS-232-C interface, a cable must be attached between the Front End and either a modem or the host itself. Use the following steps to interconnect the system you have chosen to use. Each network type has its own set of instructions.

TWO-POINT DIRECT-CONNECT NETWORK

1. Connect one end of an RS-232-C Null-Modem Cable (such as the Fluke Accessory Y1702 Two-Meter Null-Modem Cable) to the male 25-pin D-type connector on the Front End.

2. Connect the other end of the Null Modem Cable to the RS-232-C connector on the host computer.

TWO-POINT WITH MODEMS OVER A DEDICATED LINE

1. Connect one end of a standard RS-232-C cable (such as the Fluke Accessory Y1707 Two-Meter Cable) to the male 25-pin D-type connector on the Computer Front End.

2. Connect the other end of the cable to the RS-232-C connector on the modem.

3. Make similar connections between the host computer and its modem (follow the instructions supplied with the modem).

LINKING TO TELEPHONE SERVICE WITH AN AUTO-ANSWER MODEM

1. Connect one end of a standard RS-232-C cable (such as the Fluke Accessory Y1707 Two-Meter Cable) to the male 25-pin D-type connector on the Front End.

2. Connect the other end of the cable to the auto-answer modem, following the instructions for that particular modem.

When the communication session is complete, the host computer transmits the character sequence DLE EOT to the Front End. On recognition of this character sequence, the Front End asserts CD (Data Terminal Ready) low, telling the modem to hang up the telephone line. CD is also set low to disconnect the line if at any time the Front End detects signal CF (Received Line Signal Detect) to be low for more than 10 seconds. This could be caused by line interruption, or by the host computer hanging up at its end of the line.

RS-422 Signal Descriptions

Electronic Industries Association (EIA) standard RS-422 gives the specifications for the "electrical characteristics of balanced voltage digital interface circuits." The RS-422 interface uses a balanced (differential) voltage signal. This allows digital communication over as much as 4,000 feet of twisted-pair 24 AWG wire at bit rates up to 19,200 baud. Two-point and multipoint configurations can be used with RS-422.

The standard is only an electrical standard; it does not define the mechanical interface characteristics. When S1 on the Computer Interface Module is set to the RS-422 positions, the Front End presents the RS-422 signal connections on the same subminiature 25-pin D-type connector as it uses for the RS-232-C signals. Table 3-4 lists the six signals used by the RS-422 interface on the Front End and gives their pin assignments.

Table 3-4. RS-422 Signals and Associated Pin Assignments

Pin Number	Signal Name	Direction
1	Shield	(Chassis Ground)
14	R+	From Host Computer
15	R-	From Host Computer
9	T+	To Host Computer
10	T-	To Host Computer
7	Common	(Signal Common)

The following is a description of each of the RS-422 Interface signals to help you understand better how the RS-422 Interface works.

- o Shield
  Shield is the direct connection to chassis ground for the shield around the twisted-pair cable between the host computer and the Front End. Shield is used when the devices at both end of the communication line have the same chassis potentials. This is the case when the AC power grounds at each end are the same.

- R+

  R+ is one of two differential received data signals from the host computer. R+ is the logical inverse of R-. When R+ is greater than 0.2 volts more positive than R-, the received data signal is considered to be a logic 1 (or mark) state. This is the normal state of the interface and corresponds to a stop bit. When R+ is greater than 0.2 volts more negative than R-, the data signal is considered to be a logic 0 (or space) state. The space state represents a start bit at the beginning of character transmission.

- R-

  R- is the other of the two differential data signals received from the host computer. R- is the logical inverse of R+.

- T+

  T+ is one of two differential data signals transmitted to the host computer. T+ is the logical inverse of T-. When T+ is greater than 0.2 volts more positive than T-, the transmitted data signal is considered to be in a logic 1 (or mark) state. This is the normal state of the interface and corresponds to a stop bit. When T+ is greater than 0.2 volts more negative than T-, the data signal is considered to be in a logic 0 (or space) state. This is the state in which the interface generates a start bit at the beginning of character transmission.

- T-

  T- is the other of the two differential data signals transmitted to the host computer. T- is the logical inverse of T+.

- Common

  Common is the common reference signal for R+, R-, T+, and T-.

CABLE CONNECTIONS

The Front End can be used as an RS-422 interface in two different system configurations. The simplest configuration is two-point, where a host computer is connected to a single Front End. The other possible configuration is multipoint, where several Front Ends are addressable separately by a host computer.

TWO-POINT CONFIGURATION

After configuring and installing the Computer Interface Module, connect the Front End for two-point RS-422 operation as follows:

1. Obtain the desired length of shielded cable containing at least three twisted-pairs of conductors (minimum size 24 AWG).

2. Referring to Table 3-4 for pin assignments, install a 25-pin, subminiature D-type connector on the end of the cable that will connect to the Front End. Make the following pin connections:

3. Connect one twisted pair to pins 9 and 10 (T+, T-).

4. Connect another twisted pair to pins 14 and 15 (R+, R-).

5. Connect one conductor of the third twisted pair to pin 7 (common).

6. Connect the cable shield(s) to pin 1.

7. Install an appropriate connector for the host computer end of the cable, making sure to attach the correct signal lines to each pin, matching the requirements of the host computer.

MULTIPOINT CONFIGURATION

After configuring, setting the multipoint address, and installing the Computer Interface Module in each Front End, connect the Front Ends for multipoint RS-422 operation as follows:

1. Attach the Y1060 Serial Link Multi-Connectors. Refer to Figure 3-6 for a typical RS-422 multipoint configuration. A female (two cable) Y1060 end attaches to the Host Computer connector on each Front End (CFE) except the last.

2. Determine requirements for cables "A", "B", and "C" in Figure 3-6.

   o Cable length: Prepare the required lengths of shielded, twisted-pair cables. Each cable must contain at least three twisted pairs (minimum size 24 AWG). Refer to Figure 3-6 for a glimpse of cable requirements in an RS-422 multipoint configuration.

   o Connectors: Determine required connector gender. Remember that each Y1060 supplies one male and one female single-cable connector. The cable "C" connector at CFE#3 should be female.

3. Install the cable connectors associated with CFE#1, CFE#2, and CFE#3. Refer to Table 3-4 for pin assignments.

   a. Connect one twisted pair to pins 9 and 10 (T+, T-).

   b. Connect another twisted pair to pins 14 and 15 (R+, R-).

c. Connect one conductor of a third twisted pair to pin 7 (common).

d. Connect the cable shield(s) to pin 1.

4. At the host computer end of cable "A", install a male (or female) connector, as required. Make sure that the lines connected here match host computer signal requirements.

5. Attach cables "A", "B", and "C" (Figure 3-6).

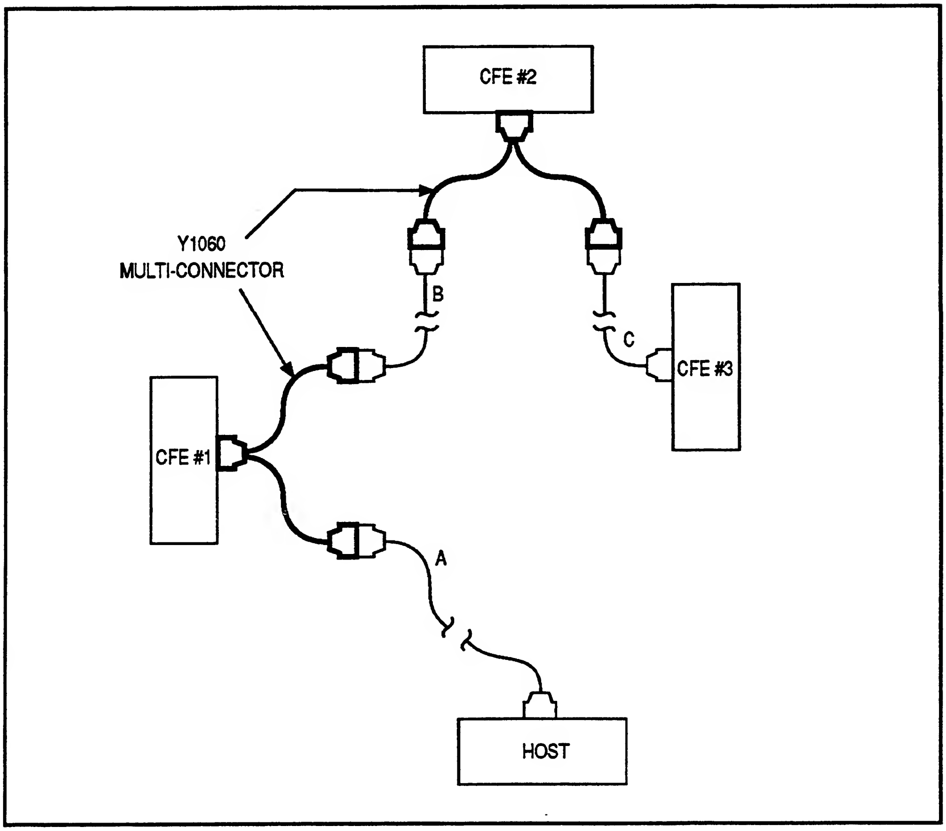


Figure 3-6. RS-422 Multipoint Cabling Configuration

In a multipoint direct-connect system (RS-422), each Front End in the system has a unique address. Up to ten Front Ends may be connected in such a system. Each Front End in the system is assigned an address from zero to nine, as set on the ADDRESS switch (S3) on the Computer Interface Module. After one Front End is addressed, the other Front Ends remain idle until there is another address sequence.

In a two-point network, there is no establishment procedure, since there is only one Front End. In a multipoint network, however, a logical connection must be established between the host and only one Front End at a time.

The host establishes an RS-422 communication link between itself and a particular Front End in a multipoint network as follows:

1. The host sends an address character followed by the Enquiry character, ENQ. The address character is the mathematical sum of the address (0 - 9) and ASCII-coded character "0" (ASCII decimal 48).

2. When a Front End detects its address sequence, it responds by echoing its address character, followed by the Acknowledge character (ACK), establishing the connection.

NOTE

When using a multipoint system, make sure that only one Front End is addressed at a time. The recommended way of doing this is to perform the termination sequence prior to addressing any Front End.

CONNECTING TO THE PRINTER PORT

The following section deals with connecting to the Printer Port. This is an output port only and is intended to be connected to an RS-232C printer or display monitor.

Setting the Communication Switches

The Printer Port must be configured so the communication characteristics match those of the printer or display monitor. Table 3-5 shows the configuration of the Printer Port as it is shipped from the factory.

Table 3-5. Default Printer Port Communication Parameters

BAUD RATE	9600
PARITY	NONE
NUMBER OF DATA BITS	8
NUMBER OF STOP BITS	1

If these settings do not match your chosen printer or display terminal, you will have to change the settings of the Front End. To begin, refer to the "Line Power Voltage Selection" procedure in the previous section to remove the Computer Interface Module.

Figure 3-5 shows the location of the printer port communication parameter selection switch (S4). The Table within the Figure show the settings needed to configure the Front End for various Baud Rates and Data Configurations.

NOTE

The switch is shown in the position as shipped (white = pressed).

RS-232-C Printer Port Signal Descriptions

The Printer Port is implemented as a data terminal equipment (DTE) as described by Electronic Industries Association (EIA) standard RS-232-C. As a DTE unit, the equipment must be connected to a data communication equipment (DCE). As most printers and terminals are also DTE equipment a Null Modem must be used to properly interface with them. Modems and null-modem cables are examples of DCE.

Table 3-6 lists the RS-232-C signals used by the Printer Port, their functions and pin assignments.

Table 3-6. RS-232-C Circuits Supported By The Printer Port

Pin Number	Circuit Name		Direction
1	AA	Protective Ground	(Chassis Ground)
2	BA	Transmitted Data	To Printer
3	BB	Received Data	From Printer
4	CA	Request to Send	To Printer
5	CB	Clear to Send	From Printer
6	CC	Data Set Ready	From Printer
7	AB	Signal Ground	(Reference Ground)

CONNECTING ALARM ANNUNCIATORS

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO. HIGH VOLTAGES MAY EXIST ON THE WIRES TO THE ANNUNCIATOR CONNECTOR DURING NORMAL OPERATION. THESE VOLTAGES SHOULD BE REMOVED PRIOR TO SERVICING THE CONNECTOR

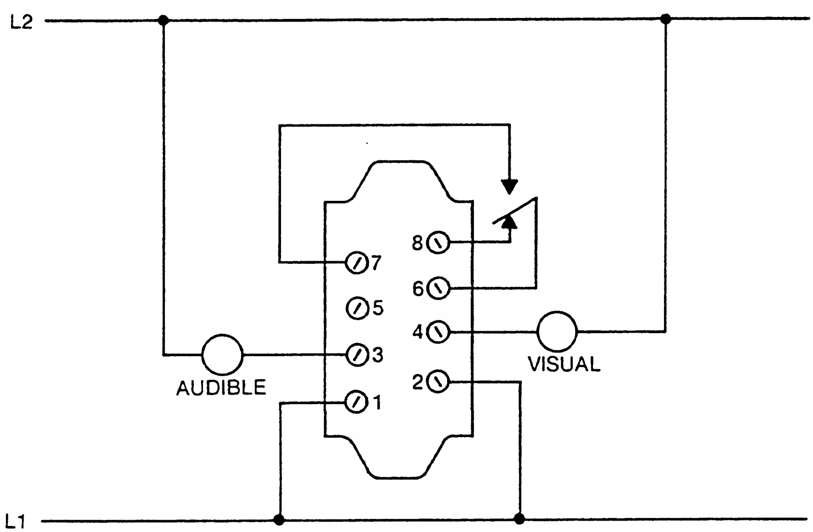
The alarm annunciator is connected as shown in Figure 3-7. Use maximum wire size of 12AWG, stripped to expose a maximum of 1/4 inch (6.4mm) of bare wire. Caution must be exercised to insure that all strands of the wire are properly inserted in the connector opening. The clamping screw must be turned all the way down to insure that the wire is properly secured in the connector.

Proper alarm annunciator connections allow for the following operating sequence:

- When an alarm is detected, the audible alarm contacts (pins 1 & 3) close and the visual alarm contacts (pins 2 & 4) begin opening and closing about once every 800 milliseconds (1.25 Hz). This action continues until the alarm condition is acknowledged. Once acknowledged, the audible alarm contacts open, and the visual alarm contacts close and remain closed. When the alarm condition is removed, the visual alarm contacts open and remain open.

- o In the event the alarm condition is removed prior to the time the alarm is acknowledged, the visual alarm contacts continue to open and close, and the audible alarm contact remains closed. In this case, when the alarm is acknowledged, both the visual and audible alarm contacts return to their normally open state.

- o The alarm acknowledge sequence requires, first, that a connection be made between pins 8 & 6. This connection must then be removed and a connection made between pins 6 & 7. This connection must now be removed and the connection between pins 8 & 6 re-established. This is the action that occurs when a single-pole/double-throw pushbutton is used, as shown in Figure 3-7. This sequence of actions is required to prevent the alarm acknowledge contacts from being permanently wired in the acknowledged position. For safety reasons, operator action is required to acknowledge the alarm.



WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT L1 AND L2 BEFORE MAKING ANY ALARM CONNECTIONS.

Figure 3-7. Typical Alarm Wiring

THE OPTIONS

The use of option cards allows for a wide range of Front End configurations. The option cards slip into position easily from the rear panel of either the Front End or the 2281A Extender Chassis.

The options are identified by three-digit number as follows:

-160 AC Voltage Input Connector
-161 High Performance A/D Converter
-162 Thermocouple/DC Volts Scanner
-163 RTD/Resistance Scanner
-164 Transducer Excitation
-165 Fast A/D Converter
-167 Counter/Totalizer
-168 Digital I/O Assembly
-169 Status Output Connector
-170 Analog Output
-171 Current Input Connector
-174 Transducer Excitation Connector
-175 Isothermal Input Connector
-176 Voltage Input Connector
-177 RTD/Resistance Input Connector
-179 Digital/Status Input Connector

SYSTEM CONSIDERATIONS

At this point, consider the nature of your Front End system. Below are five important system set-up considerations. If any of these issues has not already been resolved, please read the general installation information that follows. If you are satisfied with your system design, or if you just need more specific information about an option, refer to the appropriate subsection at the end of this section. Each subsection is identified by three-digit option number.

1. Identify System Requirements

   What measurement functions are required?
   What output functions are required?
   How many channels are required?

2. Define the Options Required

   What option cards are necessary to fulfill system requirements?

3. Load the Options

   Which options double-up in the same slot?
   Which options must be installed adjacent to each other?
   How do the options fit into the general slot-loading hierarchy?

4. Determine Additional Power Requirements

   If one or more Extender Chassis is used, what additional power will the Front End have to provide?
   Is an additional power supply needed?

5. Set-Up the Channel Addressing Scheme

The following pages answer these questions.

1. IDENTIFY SYSTEM REQUIREMENTS

What do you plan to do with the Front End? Many types of inputs can be measured, and both status and analog outputs can be specified. This manual deals with Front End functions under the following categories:

Analog Output
Current Measurement
Digital/Status Input
Frequency Measurement
Resistance Measurement
Status Output
Strain Measurement
Temperature Measurement Using RTDs
Temperature Measurement Using Thermistors
Temperature Measurement Using Thermocouples
Totalizing Measurement
Voltage Measurement - AC
Voltage Measurement - DC

One of these categories satisfies virtually any measurement or output function.

2. DEFINE THE OPTIONS REQUIRED

The Table 3B-1 identifies the options that are required for each function. The list also shows how many measurement channels are available with each option or combination of options. Three terms are used:

- o Chan (channel): a discrete measurement or output path. Typically, each option handles several channels.
- o Assy (assembly): an option or set of options occupying a single slot in the Front End or Extender Chassis.
- o Unit: The Front End or a 2281A Extender Chassis.

Most of the option cards perform measurement functions. These cards can be classed either as connectors, allowing for external wire routing and attachment, or as scanners, providing measurement signal conversions for the -161 High Performance A/D Converter and interfacing to the Front End or Extender Chassis.

- o Connectors: -160, -171, -175, -176, -177, -179.
- o Scanners: -162, -163.

If the -161 High Performance A/D Converter is used, scanner/connector pairs occupy a separate slot. If the -165 Fast A/D Converter is used, the -175 or -176 Connector can be attached directly to the converter in the same slot.

In addition, the -167 option card performs its measurements using its own terminal block for external connections.

The -168 option requires either a -169 connector or a -179 connector.

The -174 connector and -164 option card aid in several measurement functions by providing a voltage or current source for external transducers.

Table 3B-1. Option Requirements

FUNCTION	OPTION CARDS A/D	SCANNER or EXCITATION	CONN	CHAN/ ASSY	ASSY/ UNIT	CHAN/ UNIT
TEMPERATURE						
Thermocouple	-161	-162	-175	20	5	100
	-165		-175	20	6	120
RTD						
Config A	-161	-163	-177	20	5	100
Config B		-164	-174	20	2	40
	-161	-162	-175/176			
Config C		-164	-174	20	3	60
	-165		-175/176			
Thermistor	-161	-163	-177	20	5	100
VOLTAGE						
AC	-161	-162	-160	10 ac/ 10 dc	5	50 ac/ 50 dc
DC	-161	-162	-175/176	20	5	100
	-165		-175/176	20/40	6	120/240
CURRENT						
	-161	-162	-171	20	5	100
	-165		-175/-176**	20	6	120

Table 3B-1. Option Requirements (cont)

FUNCTION	OPTION CARDS A/D	SCANNER or EXCITATION	CONN	CHAN/ ASSY	ASSY/ UNIT	CHAN/ UNIT
RESISTANCE						
Config A	-161	-163	-177	20	5	100
Config B		-164	-174	20	2	40
	-161		-175/176			
Config C		-164	-174	20	3	60
	-165		-175/176			
STRAIN		-164	-174			
	-161	-162	-175/176	20	2	40
FREQUENCY	-167		included	6	5	30*
TOTALIZING	-167		included	6	5	30*
DATA INPUT (Binary/BCD)	-168		-179	1	6	6
STATUS INPUT	-168		-179	20	6	120
STATUS OUTPUT	-168		-169	20	6	120
ANALOG OUTPUT	-170		included	4	5	20*

* Due to power requirements, do not use sixth position.

** With shunt resistors mounted on screw terminals

Conversion of analog measurements to a digital format is accomplished with either of two configurations:

- o -161 High Performance A/D Converter, using -162 Scanner (with -160, -171, -175, or -176 Connector) or -163 Scanner (with -177 Connector).
- o -165 Fast A/D Converter, with -175 or -176 Connector attached in same slot, or

The -168 option card accepts the -179 connector for digital/status inputs. An a/d converter (-161 or -165) is not required for such non-analog inputs. The -168 option card accepts the -169 connector for status outputs.

The -170 Analog Output option card provides voltage or current outputs to connection points on its own terminal block.

The Front End system accommodates a maximum of 1000 input and output channels. This total is met with options installed in multiple system units (Front End and 2281A Extender Chassis). Six option slots are available in each unit. The number of channels supported by each unit depends on the option types.

3. LOAD THE OPTIONS

At this point, you have already defined the Front End functions needed in your system, the types of options to support those functions, and, probably, the number of option cards needed. Now, you need to determine the best positioning for these cards in the Front End and Extender Chassis.

Each unit (Front End or Extender Chassis) provides six option slots. One, two, or three slots may be needed per function. In addition, certain slots are preferred for performance and interconnection considerations. A few recommendations aid in placing an option mix.

Categorize the Options

Separate the options into stand-alone and interdependent categories. Differentiate the two by the number of slots required to perform a function. A function requiring one slot, whether using a single card or a card-connector combination, defines a stand-alone option. Interdependent options use more than one slot to perform a function.

- o Stand-alone options:
  - Fast A/D Converter (-165) with -175 or -176 connector attached directly
  - Counter/Totalizer (-167)
  - Digital I/O Assembly (-168) with connector (-169 or -179)
  - Analog Output (-170)

- o Interdependent options:
  - High Performance A/D Converter (-161) and one or more analog scanner/connector pairs. (-162 and -160 or -171 or -175 or -176) (-163 and -177)
  - High Performance A/D Converter (-161) with one or two combinations of analog scanner/connector and Transducer Excitation Module/Connector. (-162 and -175 or -176 // -164 and -174)

Load Stand-Alone Options in Upper Slots

Load stand-alone options in the upper slots. These options include:

Fast A/D Converter with -175/-176 Connector	
Analog Outputs	
Counter/Totalizers	(any order)
Digital Scanners	

Load Interdependent Option Sets at the Bottom

Load interdependent option sets below the stand alone options. Load scanner/connector pairs first (bottom up), followed by the associated High Performance A/D Converter. Load a Transducer Excitation Module/Connector pair immediately below the related scanner/connector.

```
        ^      -161 High Performance A/D Converter
        ^      Analog scanner/connector
        ^      Transducer Excitation Module/Connector
  (bottom)
```

For two scanner/connector - Transducer Excitation sets:

```
        ^      -161 High Performance A/D Converter
        ^      Analog scanner/connector
        ^      Transducer Excitation Module/Connector
        ^      Analog scanner/connector
        ^      Transducer Excitation Module/Connector
  (bottom)
```

For multiple scanner/connector sets:

```
        ^      -161 High Performance A/D Converter
        ^      Analog scanner/connector
               .
               .
        ^      Analog scanner/connector
  (bottom)
```

If two High Performance A/D Converters are being used in the same unit and a vacant slot is available, leave a blank slot between the converter-scanner sets.

```
        ^      -161 High Performance A/D Converter
        ^      Analog scanner/connector
  (blank)
        ^      -161 High Performance A/D Converter
        ^      Analog scanner/connector
  (bottom)
```

4. DETERMINE ADDITIONAL POWER REQUIREMENTS

General

Option assemblies receive power from either the Front End power supply (supplying 12V) or the optional -431 Power Supply (supplying 20 volts). The serial link cable distributes power both from the Front End and between Extender Chassis.

Care must be taken to insure that all options have enough power available to function properly. Two factors must be considered:

1. The power consumption of each option receiving power directly from the serial link.

2. The distance from the power supply to the options.

Maximum Power Required

Total power available to option assemblies is:

- 21 watts from the Front End.

- 20 watts from a -431 power supply, which must be derated for operating temperatures above 40 °C (see the 2281A Manual for details).

If the Extender Chassis is located more than 2 meters from the mainframe, a -431 Power Supply is required.

Power requirements for option assemblies are summarized in Table 3B-2. Option assemblies not mentioned in this table receive power over the serial link from one of the options in Table 3B-2. For example, the -175 connector and the -162 scanner receive power from the -161 High Performance A/D Converter. Maximum power requirements mentioned in this table cover both the option mentioned and related options powered from that option.

Table 3B-2. Typical Power Consumption

OPTION	TYPICAL POWER
-161 High Performance A/D Converter	2.3W
-162 Thermocouple/DC Volts Scanner	
Initial option	0.5W
Each additional option	0.2W
-163 RTD/Resistance Scanner	
Initial option	1.1W
Each additional option	0.5W
-164 Transducer Excitation Module	3.5W
-165 Fast A/D Converter	3.0W
-167 Counter/Totalizer Assembly	4.3W
-168 Digital Input/Output	1.5W
-170 Analog Output	4.1W

EXAMPLE 1

FRONT END		2281A EXTENDER CHASSIS	
Option	Watts	Option	Watts
-161	2.3	-170	4.1
-162	0.5	-170	4.1
-164	3.5	-168	1.5
-161	2.3	-168	1.5
-162	0.5	-168	1.5
-164	3.5	-168	1.5

Total power requirement = 26.8 watts. A -431 is needed.

EXAMPLE 2

FRONT END Option	Watts	2281A EXTENDER CHASSIS Option	Watts
-168	1.5	-161	2.3
-167	4.3	-162	0.5
-161	2.3	-164	3.5
-162	0.5	-	-
-162	0.2	-	-
-163	1.1	-	-

Total power consumption = 16.2W. A -431 is not required if the Extender Chassis is located within 2 meters of the Front End.

Serial Link Cable Length

The length of the serial link cable is an important consideration in supplying sufficient voltage to all options assemblies. Voltage drops along the cable limit the power available. When the voltage at the option drops below 12 volts, the respective power requirement can no longer be met. The -431 power supply can then be used to provide a voltage boost.

The 2281A Extender Chassis Instruction Manual provides extensive guidance in determining the need for and placement of -431 power supplies. This information can be used for the Front End, with one reservation. The 2281A Instruction Manual documents the 2280A Datalogger, which uses a 24 volt power supply. The Front End power supply provides 12 volts. Therefore, only minimal distances (2 meters) can be allowed between the Front End and external options in an extender chassis. Since the -431 power supply provides 20V, distances between a -431 and external options can be greater.

If the first 2281A Extender Chassis is more the 2 meters from the Front End, a -431 is required in that 2281A. Other -431 power supplies may be required where multiple extender chassis are used. Refer to the 2281A Instruction Manual.

5. SETUP THE ADDRESSING SCHEME

With the option configuration established, the final step involves setting up a consistent addressing pattern. A unique block of addresses must be reserved for each option. Addresses 000 through 999 are available and are partitioned in two ways.

- o Options with Address Switches

  Switches on the option assemblies are used to assign address blocks directly for these options:

  -161 High Performance A/D Converter
  -165 Fast A/D Converter
  -167 Counter/Totalizer Assembly
  -168 Digital/Status I/O
  -170 Analog Output

- o Options without Address Switches

  Other options derive addresses from their position relative to the address switch-equipped options. These indirectly-addressed options are:

  -162 Thermocouple/DC Volts Scanner
  -163 RTD/Resistance Scanner
  -164 Transducer Excitation Module
  -169 Status Output Connector
  -171 Current Input Connector
  -174 Transducer Excitation Connector
  -175 Isothermal Input Connector
  -176 Voltage Input Connector
  -177 RTD/Resistance Input Connector
  -179 Digital/Status Input Connector

Selecting unique addresses for a small system is easily accomplished. For larger systems, a little planning is in order. Situating the a/d converter(s) is the most important step. Other option assemblies can then be arranged to fill out the system.

High Performance A/D Converters only, Fast A/D Converters only, or a combination of a/d converter types is acceptable. Each -161 High Performance A/D Converter reserves a 100-address block, while each -165 Fast A/D Converter reserves a 40-address block. The size of the a/d converter address block can be important to the flexibility of an addressing system, as is shown in the descriptions and examples below.

For the -168 Digital I/O Assembly, addressing depends on the type of associated connector assembly. If the -169 Status Output Connector is used, the address setting reserves a 20-channel block. If the -179 Digital/Status Input Connector is used, the address setting reserves a 20-channel block when used with status inputs, but only a 10-channel block when used with digital inputs.

Status input and output addresses each reserve a block of 20 channels. The -179 connector is attached to the -168 Digital I/O Assembly for status inputs, and the -169 connector is used in a similar fashion for status outputs. For maximum utilization of available channels, only even addresses should be used. The use of odd addresses results in fewer available channels. Table 3B-3 summarizes status input/output addressing.

Table 3B-3. Status Input/Output Addressing

ADDRESS SWITCH SETTING	ADDRESSES RESERVED AND USABLE
0 0	0 - 19
0 2	20 - 39
0 4	40 - 59
0 6	60 - 79
0 8	80 - 99
1 0	100 - 119
1 2	120 - 139
.	.
.	.
9 8	980 - 999

Although each Digital I/O Assembly reserves 10 channels, it can support only one digital (BCD or binary) input. As required by the addressing scheme, this input can be addressed as 0, 10, or any multiple of 10. This arrangement is summarized in Table 3B-4.

Table 3B-4. Digital Input Addressing

ADDRESS SWITCH	CHANNELS RESERVED	CHANNEL USED
0 0	0 .. 9	0
0 1	10 .. 19	10
0 2	20 .. 29	20
.	.	.
1 1	110 .. 119	110
.	.	.
9 9	990 .. 999	990

Using the -161 High Performance A/D Converter

Set each -161 to a unique 100's address block. Options associated with a -161 High Performance A/D Converter assume addresses that are dependent on their position relative to the -161. Each -161 option reserves a block of 100 addresses. The -164 (if installed directly below the -161), -162, and -163 derive their addresses in this manner. Each uses a block of 20 addresses.

1. Count the number of options that are used with and installed under a -161.

2. Multiply this number by 20, and add the hundreds address of the -161. This calculation yields the beginning address used in the next available block.

3. Repeat steps 2 and 3 for each -161 in the system.

4. Set each -167, -168, and -170 to unique 100's and 10's addresses (not used by options associated with a -161).

NOTE

If a -168 is used as a Status Input or Status Output, the 10's address following the selected address is not available.

Table 3B-5. High Performance A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	High Performance A/D Converter CHANNEL RANGE
0 0	0-99
1 0	100-199
2 0	200-299
3 0	300-399
4 0	400-499
5 0	500-599
6 0	600-699
7 0	700-799
8 0	800-899
9 0	900-999
10 0 .. 15 0	(not used)

Example (-161 High Performance A/D Converter Configuration)

For example, set up the addressing pattern for a system with the following options:

1. A -161 with -162, -164, and -163 associated directly below.

2. A -161 with five -162's associated directly below.

3. A -167.

4. A -168 set for Status Input.

5. A -170.

An acceptable top-to-bottom option configuration is shown in Table 3B-6.

Table 3B-6. Example (-161 Configuration)

Option	Assigned 100's	10's	Used
-161	0	-	-
-162	-	-	0 - 19
-164	-	-	20 - 39
-163	-	-	40 - 59
-168	0	6	60 - 79
-170	1	0	100 - 103
-161	2	-	-
-162	-	-	200 - 219
-162	-	-	220 - 239
-162	-	-	240 - 259
-162	-	-	260 - 279
-162	-	-	280 - 299
-167	3	1	310 - 315

Using the -165 Fast A/D Converter

A maximum of 20 Fast A/D Converters can be used in a Helios Plus system. Base addresses for the -165 Fast A/D Converter are available in multiples of 50 (0, 50, etc). Each -165 a/d converter uses the first 40 of these addresses (0..39, 50..89, etc). For example, if the -165 is set for the 100, addresses 100 through 139 are used for associated option assemblies.

The -175 and -176 connector options assume addresses in this fashion. When used for dc volts measurements, either connector can use the full 40 channels for 20 differential measurement pairs or 40 single-ended measurements.

Inputs to the -165 Fast A/D Converter can be used as 40 single-ended channels (for example, 0 through 39) or as 20 differential channels (0 through 19). Channels 20 through 39 are then used to form the differential pairs (0/20, 1/21, etc). A reading on differential channel 20 is the same as on differential channel 0.

Table 3B-7 shows the overall address block scheme for the -165 Fast A/D Converter. This scheme offers greater flexibility in that more address blocks are available; devoting a small set of addresses to a full block ties up only 40% of the addresses (40) when compared with the -161 High Performance A/D Converter (100).

Table 3B-7. Fast A/D Address Switch Settings and Channel Ranges

SWITCH SETTING	BASE ADDRESS	ADDRESSES AVAILABLE FOR: -165 OPTIONS	OTHER OPTIONS*
0 0	0	0..39	40..49
0 5	50	50..89	90..99
1 0	100	100..139	140..149
1 5	150	150..189	190..199
2 0	200	200..239	240..249
2 5	250	250..289	290..299
3 0	300	300..339	340..349
3 5	350	350..389	390..399
4 0	400	400..439	440..449
4 5	450	450..489	490..499
5 0	500	500..539	540..549
5 5	550	550..589	590..599
6 0	600	600..639	640..649
6 5	650	650..689	690..699
7 0	700	700..739	740..749
7 5	750	750..789	790..799
8 0	800	800..839	840..849
8 5	850	850..889	890..899
9 0	900	900..939	940..949
9 5	950	950..989	990..999
10 0 .. 15 0		(not used)	

Table 3B-7. Fast A/D Address Switch Settings and Channel Ranges (cont)

* Each Fast A/D Converter reserves the first 40 addresses in a 50-address block (50..89 of 50..99, etc.), the unused 10 addresses (90..99) can be used for these options:

-167 Counter/Totalizer
(requires 10 address block, uses first 6)
-170 Analog Output
(requires 10 address block, uses first 4)
-168 Digital I/O
(only if used for digital inputs)

The option assemblies listed below can be connected directly to the -165 Fast A/D Converter. Addresses for the channels connected to these assemblies depend on the Fast A/D Converter address switch setting.

-175 Isothermal Input Connector
-176 Voltage Input Connector

Each -164 Transducer Excitation Module/-174 Transducer Excitation Connector set must be mounted directly above or below the associated -165 Fast A/D Converter. This arrangement allows for proper routing of wires to the connector (-175 or -176) mounted on the Fast A/D Converter.

Example (-165 Fast A/D Converter Configuration)

Table 3B-8. Example (-165 Configuration)

Option Assembly	Address Setting	Channels Reserved	Channels Used
-165	0 0	0 .. 39	0 .. 39
-175	-	-	0 .. 39
-167	0 4	40 .. 49	40 .. 45
-165	0 5	50 .. 89	50 .. 89
-176	-	-	50 .. 89
-164			50 .. 89
-174			50 .. 89
-170	0 9	90 .. 99	90 .. 93
-165	1 0	100 .. 139	100 .. 139
-176	-	-	100 .. 139
-168			
-179	1 4	140 .. 149	140
-165	1 5	150 .. 189	150 .. 189
-176	-	-	150 .. 189
-164	-		150 .. 189
-174			150 .. 189

Using a Combination of -161 and -165 A/D Converters

The -165 Fast A/D Converter and the -161 High Performance A/D Converter can be used in the same system. Generally, the addressing descriptions and examples already presented for each a/d converter can be combined in such a system. The following rules apply:

- First, setup the -161 a/d converters, along with associated scanners and connectors, for the lowest address blocks in the system. Remember, each -161 converter reserves 100 addresses.

- o Second, setup -165 a/d converters in blocks of 50 addresses each.

- o Third, fill in the unused addresses.

Example (-161/-165 A/D Converter Configuration)

Option Assembly	Address Setting	Channels Reserved	Channels Used
-161	0 0	0 .. 99	
-162			
-175			0 .. 19
-164			
-174			20 .. 39
-163			
-177			40 .. 59
-168	0 6		60 .. 79
-169			
-165	1 0	100 .. 139	
-175	-	-	100 .. 139
-167	1 4	140 .. 149	140 .. 145
-165	1 5	150 .. 189	
-176	-	-	150 .. 189
-170	1 9	190 .. 199	190 .. 193
-165	2 0	200 .. 249	
-176	-	-	200 .. 239
-168	2 5		
-179		250 .. 279	250 .. 279

INTRODUCTION

The AC Voltage Input Connector attaches to the rear of the Thermocouple/DC Volts Scanner (-162) for use with the -161 High Performance A/D Converter. This combination allows for voltage measurement on 20 channels (10 for ac volts, 10 for dc volts).

- AC Volts: measurements ranging from 5V to 250V can be made on any of 10 ac channels. The voltage applied to any ac channel must not exceed 250V rms. The frequency range for ac measurements is 45 to 450 Hz.

- DC Volts: measurements up to 64V dc can be made on any of 10 dc channels.

The AC Voltage Input Connector is shown in Figure 160-1.

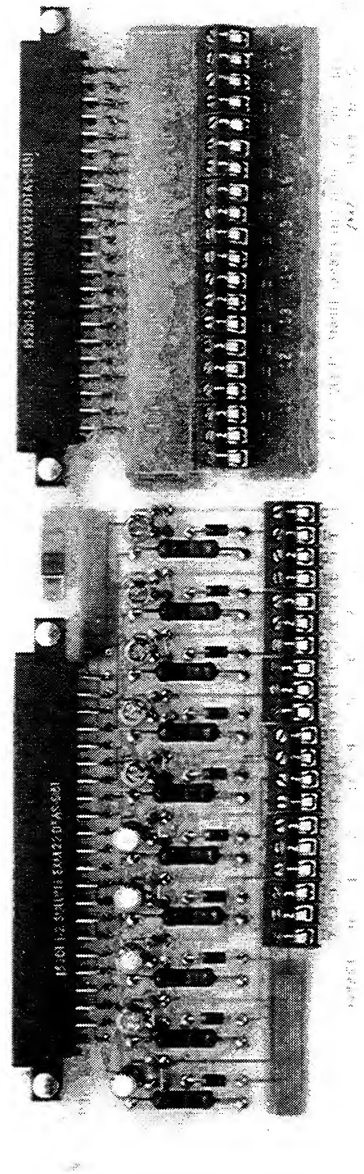


Figure 160-1. AC Voltage Input Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the AC Voltage Input Connector.

Other sections provide information related to specific applications. These include:

- Section 6L. Voltage Measurement - AC: This section discusses use of the AC Voltage Input Connector and the Thermocouple/DC Volts Scanner in measuring ac voltage.

- Other measurement functions use the dc voltage measurement capabilities of the AC Voltage Input Connector. These include

    - Section 6H: Temperature Measurement Using RTDs, Configuration B
    - Section 6M: Voltage Measurement - DC
    - Section 6G: Strain Measurement
    - Section 6E: Resistance Measurement, Configuration B

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the AC Voltage Input Connector are presented in Section 2. Section 2 also contains system accuracy specifications for ac voltage measurement.

REMOVAL AND INSTALLATION

Connections from external ac and dc voltage sources to the Front End or Extender Chassis are made via external wiring to the AC Voltage Input Connector. Preparation of the AC Voltage Input Connector involves opening the connector housing, connecting the appropriate wiring on the terminals, closing the connector housing, and reconnecting it to the Thermocouple/DC Volts Scanner (-162).

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated scanner.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set at OFF, locate the connector housing in the rear panel of the Front End.

2. Loosen the two retaining screws.

3. Firmly grasp the housing at each end and pull until the enclosed connector block is disconnected from the scanner.

Wire Connections

With the connector withdrawn from the Front End or Extender Chassis, perform the following steps:

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGES COULD OTHERWISE BE ENCOUNTERED.

1. Open the housing by pressing each locking tab.

2. The AC Voltage Input Connector is now ready to be wired to external measurement systems. For each connection, loosen the channel terminal screw, attach the external wire to the screw, then tighten the screw until the wire is firmly in place. Notice that the two terminals for each channel are marked HI and LO. Starting at Channel 0, attach the external wiring for the desired application.

NOTE

For proper reading polarity on the dc channels, ensure that the current flows into the HI terminal and out of the LO terminal.

3. Close the housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

1. With line power disconnected and the POWER switch set at OFF, position the enclosed (and wired) input connector in the guides of the rear panel slot containing the appropriate scanner.

2. Push the connector onto the card edge connector at the rear of the scanner. Press the connector firmly into place.

3. Attach the connector housing to the chassis with the two retaining screws.

INTRODUCTION

The High Performance A/D Converter (-161) provides high accuracy analog to digital conversion of scanner input voltages. For analog measurements, at least one High Performance A/D Converter must be installed. The configurations listed below are permissible:

NOTE

The configurations listed below assume a full complement of -161 High Performance A/D Converters is used in the system. A combination of -161 and -165 a/d converters or -165 a/d converters only can also be used.

- A maximum of 10 High Performance A/D Converters can be supported by the Front End with 2281A Extender Chassis.
- Each High Performance A/D Converter can support a maximum of five scanners. This limit can be filled with any combination of Thermocouple/DC Volts Scanners (-162) and RTD/Resistance Scanners (-163).
- Each scanner can support 20 measurement channels.

- o The normal capacity for the Front End Mainframe is one High Performance A/D Converter and five Scanners (i.e., 100 channels). Alternately, up to three High Performance A/D Converters could be installed in the Front End if each is associated with only one scanner.

- o These same configurations are possible with the 2281A Extender Chassis.

The High Performance A/D Converter is illustrated in Figure 161-1.

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the High Performance A/D Converter. The High Performance A/D Converter is used with analog measurement functions. These include:

- o Section 6B: Current Measurement
- o Section 6D: Resistance Measurement, Configuration B
- o Section 6H: Temperature Measurement Using RTDs, Configuration B
- o Section 6I: Temperature Measurement Using Thermistors
- o Section 6J: Temperature Measurement Using Thermocouples
- o Section 6L: Voltage Measurement - AC
- o Section 6M: Voltage Measurement - DC

Section 3C provides an installation verification procedure.

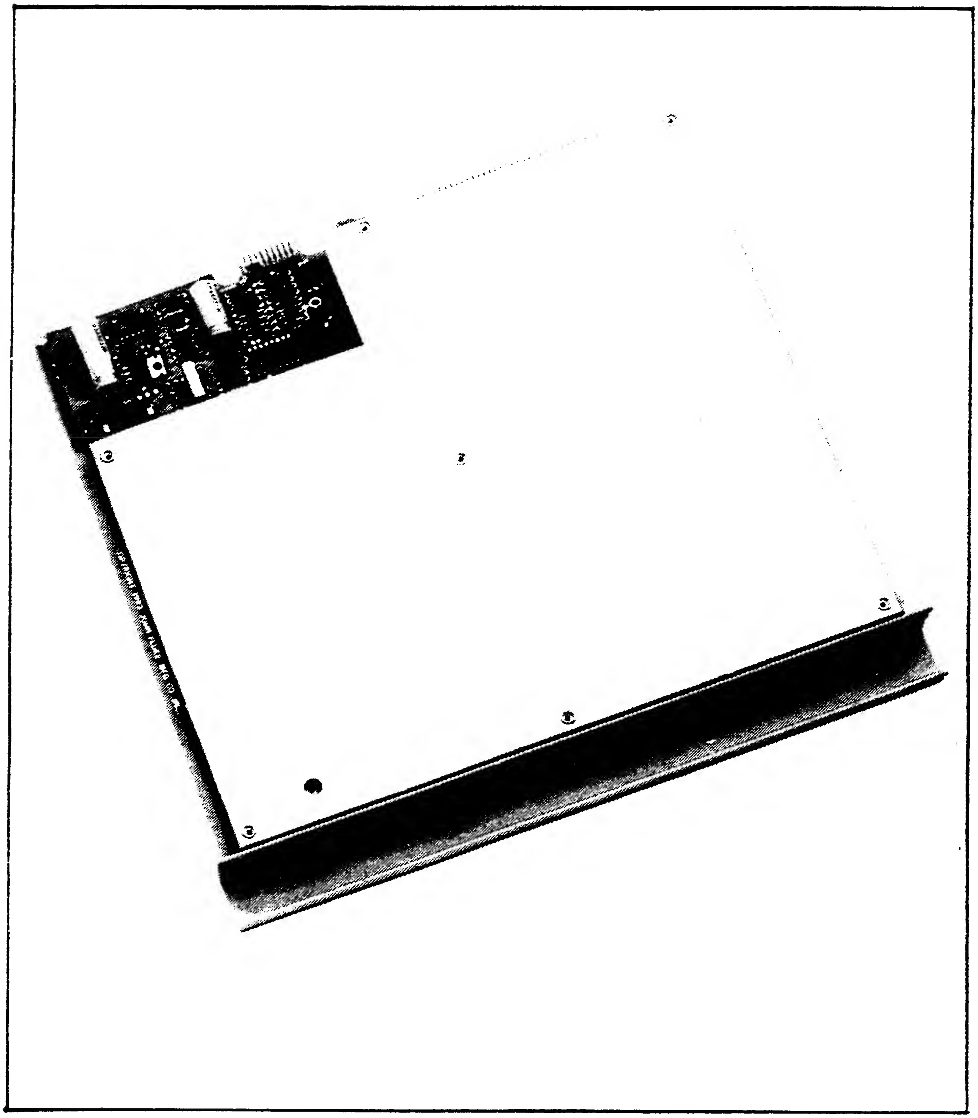


Figure 161-1. High Performance A/D Converter

SPECIFICATIONS

Specifications for the High Performance A/D Converter are presented in Section 2. Section 2 also contains system accuracy specifications for each analog measurement function supported by this A/D Converter.

HARDWARE CONFIGURATION

An address must be established for each High Performance A/D Converter installed in the system. This address identifies the range of channel numbers associated with the High Performance A/D Converter. This A/D Converter address corresponds to the "hundreds" digit of the associated channel numbers. This correspondence is defined in Table 161-1. If a High Performance A/D Converter is associated with less than 100 channels, the lowest channel addresses available (within the respective block of 100) must be used. Higher, unused addresses are thereby made available for other serial link devices.

Table 161-1. High Performance A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
0	0-99
1	100-199
2	200-299
3	300-399
4	400-499
5	500-599
6	600-699
7	700-799
8	800-899
9	900-999
10 .. 15	not used

The address switch is located in the rear left corner of the board. The switch setting can be viewed through the window labeled ADDRESS.

For each High Performance A/D Converter in your system, locate the address switch on the left corner of the A/D Converter board. Using a screwdriver, move the switch to the desired address switch setting.

The High Performance A/D Converter requires no further adjustments.

INSTALLATION

The High Performance A/D Converter is installed in the slot directly above its associated scanner(s). Each High Performance A/D Converter should be installed as follows:

WARNING

ENSURE THAT ALL POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO. PRESS THE POWER SWITCH TO OFF.

2. Locate the horizontal slot on the rear of the Front End or 2281 where the High Performance A/D Converter is to be installed. This A/D Converter should reside directly above its associated scanner(s).

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

3. Align the High Performance A/D Converter in the desired slot so that the board-edge connector is toward the motherboard in the rear of the slot. Push the board straight in until it is mated with the motherboard connectors.

4. Secure this A/D Converter to the chassis with the two retaining screws.

INTRODUCTION

The Thermocouple/DC Volts Scanner (-162) is a plug-in, one microvolt, 20-channel thermocouple and multi-voltage range relay scanner contained on a single pwb (printed wiring board). All channels are equipped with three poles, including a Shield input. The scanner operates as a self-calibrating analog multiplexer, linking the High Performance A/D Converter to external measurement points. It accepts a variety of analog inputs, depending on the type of connector in use (Current Connector, Isothermal Connector, Voltage Connector, or AC Voltage Connector).

The Thermocouple/DC Volts Scanner must be used with a High Performance A/D Converter. A maximum of five scanners can be used with a single High Performance A/D Converter. The Thermocouple/DC Volts Scanner is illustrated in Figure 162-1.

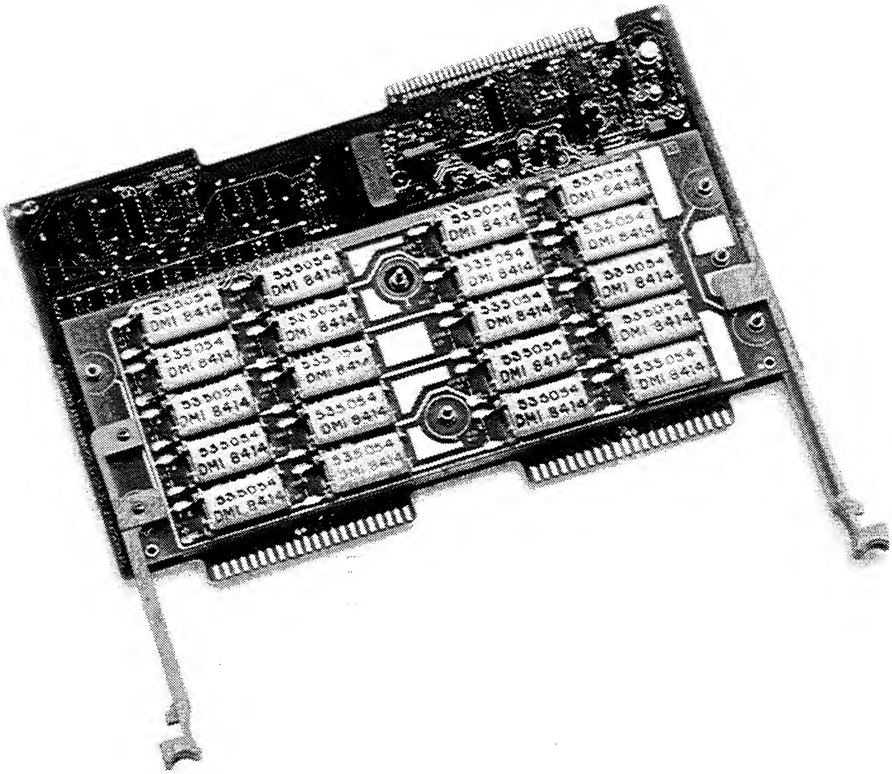


Figure 162-1. Thermocouple/DC Volts Scanner

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Thermocouple/DC Volts Scanner.

Where the Thermocouple/DC Volts Scanner is used in a specific measurement function, other sections of this manual provide more appropriate information. Examples include:

- Section 6B: Current Measurement
- Section 6E: Resistance Measurement, Configuration B
- Section 6G: Strain Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration B
- Section 6J: Temperature Measurement Using Thermocouples
- Section 6L: Voltage Measurement - AC
- Section 6M: Voltage Measurement - DC

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Thermocouple/DC Volts Scanner are presented in Section 2. Section 2 also contains separate system operating specifications for each type of measurement supported by this scanner. These include voltage, current, temperature (using thermocouples), and strain measurements. Measurements using variable resistance transducers (excited by the Transducer Excitation Module/Connector and measured as a dc voltage) are also possible.

INSTALLATION

The Thermocouple/DC Volts Scanners (up to 5 per High Performance A/D Converter) are installed in the slot(s) directly below their associated High Performance A/D Converter. Install the Thermocouple/DC Volts Scanner using the following procedure:

WARNING

ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END OR EXTENDER CHASSIS AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Press the POWER switch to OFF.

2. From the rear of the Front End, identify the mounting slot appropriate for the Thermocouple/DC Volts Scanner(s). A maximum of five scanners may be associated with one High Performance A/D Converter. All scanners must be positioned immediately below the associated High Performance A/D Converter. Any other serial link device (Counter/Totalizer, Digital I/O Assembly, Analog Output) must not interrupt this hierarchy.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

3. Align the Thermocouple/DC Volts Scanner in the desired slot. The board-edge connector must face in (toward the motherboard).

4. Secure the scanner board in the slot. Push the board straight in until it makes contact with the motherboard connectors. Then continue pressing firmly until it is mated with these connectors. Ensure that the two plastic retainer clips (on either side of the board) snap into the slots on the chassis side wall.

NOTE

To extract the scanner board, first push or pull the plastic retainer handles away from the chassis sides. Then pull the assembly straight out.

Connections must be made between the Thermocouple/DC Volts Scanner and outside measurement points. These external connections are made through a connector card attached to the scanner card. Available connectors are:

- Current Input Connector (-171)
- Isothermal Input Connector (-175)
- Voltage Input Connector (-176)
- AC Voltage Input Connector (-160)

Refer to the appropriate option subsection for complete external connection instructions.

INTRODUCTION

The RTD/Resistance Scanner is a 20-channel resistance measuring scanner. When used with the RTD/Resistance Connector (-177), it can be used to make measurements of resistances and variable resistance transducers. The RTD/Resistance Scanner is illustrated in Figure 163-1.

Resistance measurements are usually made to determine the value of some other parameter that they are directly related to, such as temperature. The Front End software provides the ability to translate resistance measurements made on RTDs into appropriate temperature readings.

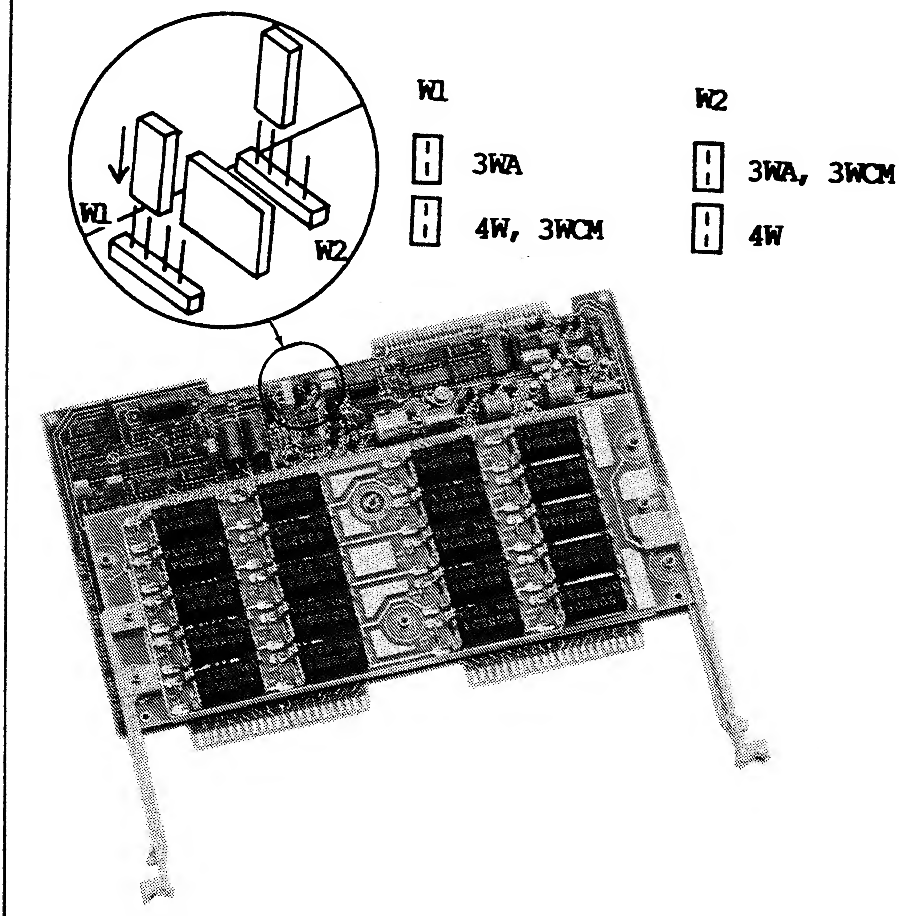


Figure 163-1. RTD/Resistance Scanner

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the RTD/Resistance Scanner.

Other sections in this manual provide more detailed information when the RTD/Resistance Scanner is to be used to implement a specific measurement function. These sections are:

- o Section 6E: Resistance Measurement
- o Section 6H: Temperature Measurement Using RTDs, Configuration A.

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the RTD/Resistance Scanner are presented in Section 2. Section 2 also contains system accuracy specifications for each type of measurement supported by this scanner. These include Temperature Measurement Using RTDs and Resistance Measurement.

HARDWARE CONFIGURATION

One measurement mode, 4-Wire (4W), 3-Wire Accurate (3WA), or 3-Wire Isolated (3WCM), must be selected prior to physically installing the scanner. This choice is made with the two jumpers shown in Figure 163-1. The measurement modes are described in Section 6E, Resistance Measurement, and Section 6H, Temperature Measurement Using RTDs.

INSTALLATION

The RTD/Resistance Scanner(s), from one to five per High Performance A/D Converter, are installed in the slot(s) directly below the High Performance A/D Converter with which they are to work. This arrangement must be maintained in the Front End mainframe and the 2281A Extender Chassis. Install each RTD/Resistance Scanner using the following procedure:

WARNING

ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END, THE 2281A EXTENDER CHASSIS, AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Press the POWER switch to OFF.

2. From the rear of the Front End or Extender Chassis, identify the mounting slot(s) appropriate for the RTD/Resistance Scanner(s). A maximum of five RTD/Resistance or Thermocouple/DC Volts scanners in any combination may be associated with one High Performance A/D Converter. All scanners that are to work with a High Performance A/D Converter must be installed immediately below that a/d converter. This order must not be interrupted by any other serial link device (such as the Counter/Totalizer, Digital I/O, or Analog Output.)

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands, while minimizing the risk of damage by static discharge.

3. Align the RTD/Resistance Scanner (component side up) in the desired slot, keeping the two plastic retainer handles located on both side edges pointed away from the motherboard.

4. Secure the scanner board in the slot, by pushing the board straight in until it makes contact with the motherboard connectors, and continuing to press firmly until the board mates fully with the connector. Ensure that the retainer handles snap into the slots on the chassis side wall.

NOTE

To extract the scanner board, first push or pull the plastic retainer handles away from the chassis sides. Then pull the assembly straight out.

Connections between the RTD/Resistance Scanner and outside measurement points are made through the RTD/Resistance Input Connector, which is attached to the rear of the scanner. Wiring from the external resistance to the connector terminals must be made while the connector is physically separated from the scanner. Refer to the RTD/Resistance Input Connector (-177) subsection for complete external connection instructions.

INTRODUCTION

The Transducer Excitation Module and the Transducer Excitation Connector (-174) provide voltage or current excitation for variable resistance transducers. Multiple functions (RTD temperature measurement, strain gauge measurement, strain-based transducers measurement, and low resistance transducer measurement) can thereby be supported.

Measuring the voltage of the stimulated transducer is accomplished with either of the following two hardware configurations:

o -161 High Performance A/D Converter, with -162 Thermocouple/DC Volts Scanner (-162) and either the Voltage Input Connector (-176), the Isothermal Input Connector (-175), or the AC Voltage Input Connector (-160).

o - 165 Fast A/D Converter, with either the -176 Voltage Input Connector or the -175 Isothermal Input Connector.

The Transducer Excitation Module is shown in Figure 164-1.

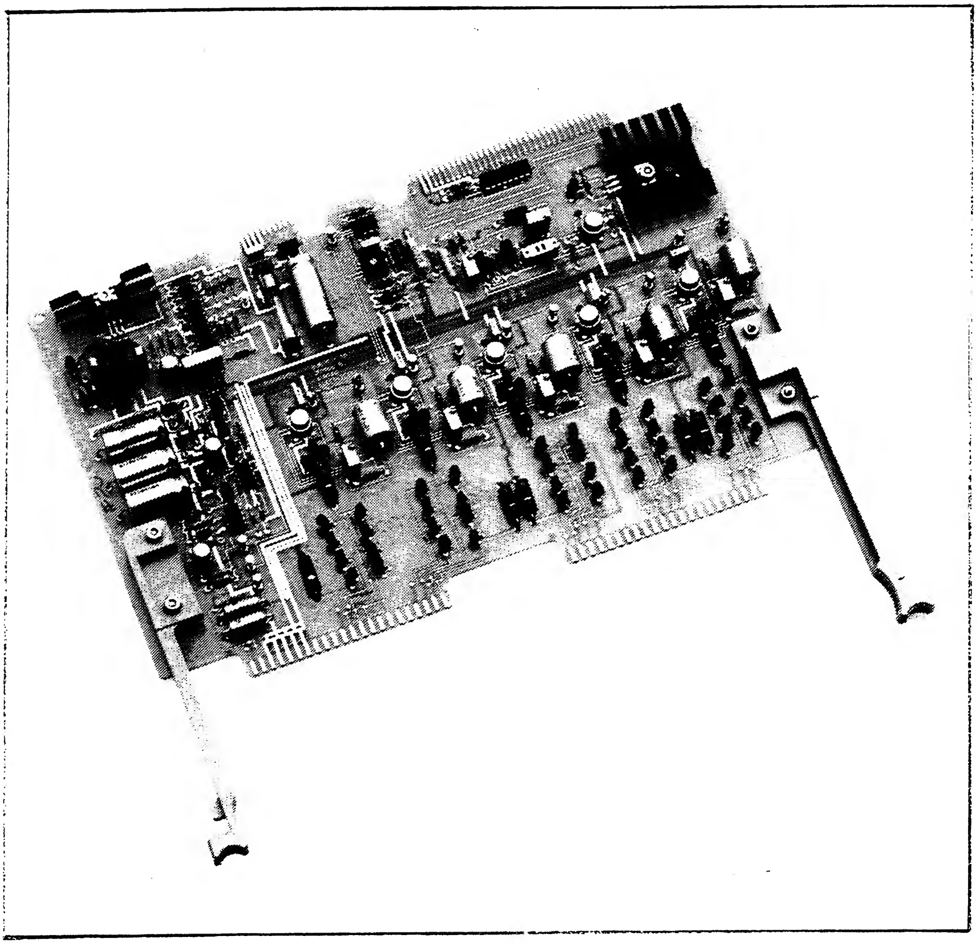


Figure 164-1. Transducer Excitation Module

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Transducer Excitation Module.

Where the Transducer Excitation Module is used in a specific measurement function, other sections of this manual provide more appropriate information. Examples include:

- Section 6E: Resistance Measurement, Configuration B
- Section 6G: Strain Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration B
- Section 6I: Temperature Measurement Using Thermistors

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Transducer Excitation Module are presented in Section 2. Section 2 also contains system accuracy specifications for each type of measurement supported by the module. These include temperature measurements (using RTDs or thermistors), strain measurements and measurements using variable resistance transducers.

HARDWARE CONFIGURATION

Voltage or current excitation is manually selected through positioning of jumper assemblies on the Transducer Excitation Connector. The voltage level, 2V or 4V, is switch-selectable on the Transducer Excitation Module. Refer to the -174 subsection.

INSTALLATION

Physical Installation

The Transducer Excitation Module is installed directly below the associated Thermocouple/DC Volts Scanner in either the Front End mainframe or the 2281A Extender Chassis. Use the following installation procedure:

WARNING

ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END, THE 2281A EXTENDER CHASSIS, AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Press the POWER switch to OFF.

2. From the rear of the Front End or Extender Chassis, identify the mounting slot(s) appropriate for the Transducer Excitation Module(s). Each module must occupy a slot immediately below the associated scanner. Any other serial link device (Counter/Totalizer, Digital I/O Assembly, Analog Output) must not interrupt this hierarchy.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

3. Align the Transducer Excitation Module in the desired slot. The board-edge connector must face in (toward the motherboard).

4. Secure the board in the slot. Push the board straight in until it makes contact with the motherboard connectors. Then continue pressing firmly until it is mated with these connectors. Ensure that the two plastic retainer clips (on either side of the board) snap into the slots on the chassis side wall.

NOTE

To extract the module, first push or pull the plastic retainer handles away from the chassis sides. Then pull the assembly straight out.

External Connections

Connections must be made between the Transducer Excitation Module and the external resistance transducer. These external connections are made through the Transducer Excitation Connector, which is attached to the rear of the module. Wiring from the external resistance to the connector terminals must be made while the connector is physically separated from the module.

The connector provides screw terminal connections for 20 channels. RTD channels each require four terminal connections. Strain gauge channels require up to five terminals each.

Channels can be connected in blocks of four, allowing a mixture of RTD and strain gauge connections to the same Transducer Excitation Connector.

Refer to the Transducer Excitation Connector subsection (-174) for complete external connection instructions.

INTRODUCTION

The Fast A/D Converter (-165) provides high-speed, high accuracy analog to digital conversion of input voltages. For analog measurements, at least one Fast A/D Converter must be installed. The configurations listed below are permissible:

NOTE

The configurations listed below assume a full complement of -165 Fast A/D Converters is used in the system. A combination of -161 and -165 A/D Converters or -161 A/D Converters only can also be used.

- A maximum of 20 Fast A/D Converters can be supported by the Front End with 2281A Extender Chassis.

- A maximum of 6 Fast A/D Converters can be supported in the Helios Plus mainframe. The 2281A Extender Chassis can also support 6 Fast A/D Converters. However, a -431 Power Supply must be added if the 2281A is more than 2 meters from the mainframe or if total system power consumption exceeds 21 watts. Refer to "4. Determine Additional Power Requirements" earlier in Section 3B.

The Fast A/D Converter is illustrated in Figure 165-1.

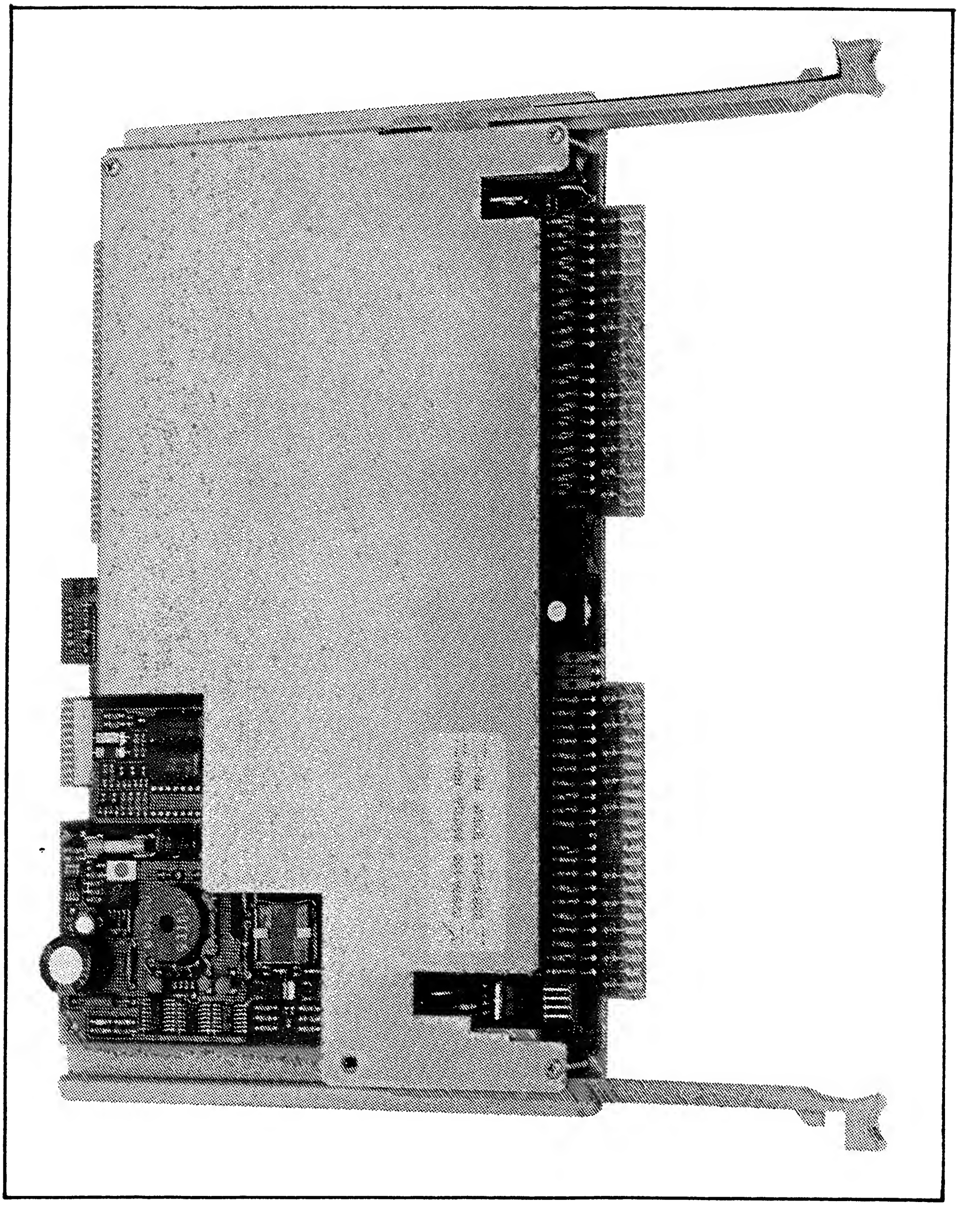


Figure 165-1. Fast A/D Converter

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Fast A/D Converter. The Fast A/D Converter is used with the following analog measurement functions:

- Section 6B: Direct Current Measurement
- Section 6D: Resistance Measurement, Configuration C
- Section 6G: Strain Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration C
- Section 6J: Temperature Measurement Using Thermocouples
- Section 6M: Voltage Measurement - DC

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Fast A/D Converter are presented in Section 2. Section 2 also contains system accuracy specifications for each analog measurement function supported by this a/d converter.

SETUP

Address Switches

Each Fast A/D Converter installed in the system must have a unique address. This address identifies the hundreds and tens digits for the range of channel numbers associated with the Fast A/D Converter. Since each Fast A/D Converter uses the first 40 channels out of a 50-channel block, each address is a multiple of 50. See Table 165-1.

If the Fast A/D Converter is used to make single-ended measurements, each of the 40 channels is unique. With differential measurements, channels are used in pairs, with members of the pair separated by 20 channels. For example, differential pairs could be channels 0 and 20 or 19 and 39. The same reading is obtained if channel 0 or 20, or channel 19 or 39 is addressed.

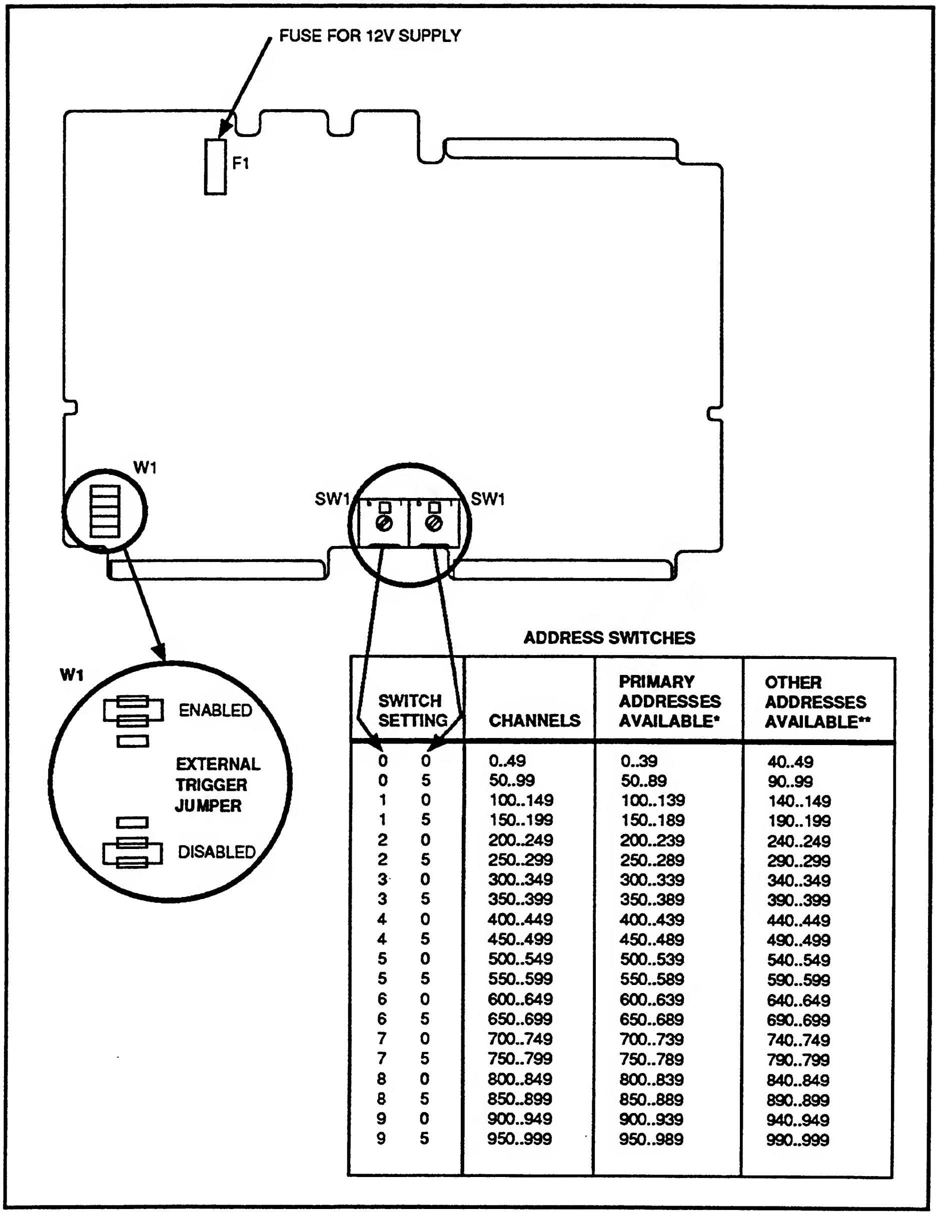
For each Fast A/D Converter in your system, locate the address switches in the center of the printed circuit assembly (pca). These switches are accessible from the rear when the a/d converter is installed. Using a screwdriver, move the switch to the desired address switch setting.

External Trigger Jumper

The XTRIG parameter of the DEF BSCAN command is used in conjunction with a hardware jumper on the Fast A/D Converter to enable one of the external triggering configurations.

Table 165-1. Fast A/D Converter Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
0	0..39
5	50..89
10	100..139
15	150..189
20	200..239
25	250..289
30	300..339
35	350..389
40	400..439
45	450..489
50	500..539
55	550..589
60	600..639
65	650..689
70	700..739
75	750..789
80	800..839
85	850..889
90	900..939
95	950..989
100 ..150	not used



SWITCH SETTING		CHANNELS	PRIMARY ADDRESSES AVAILABLE*	OTHER ADDRESSES AVAILABLE**
0	0	0..49	0..39	40..49
0	5	50..99	50..89	90..99
1	0	100..149	100..139	140..149
1	5	150..199	150..189	190..199
2	0	200..249	200..239	240..249
2	5	250..299	250..289	290..299
3	0	300..349	300..339	340..349
3	5	350..399	350..389	390..399
4	0	400..449	400..439	440..449
4	5	450..499	450..489	490..499
5	0	500..549	500..539	540..549
5	5	550..599	550..589	590..599
6	0	600..649	600..639	640..649
6	5	650..699	650..689	690..699
7	0	700..749	700..739	740..749
7	5	750..799	750..789	790..799
8	0	800..849	800..839	840..849
8	5	850..899	850..889	890..899
9	0	900..949	900..939	940..949
9	5	950..999	950..989	990..999

Figure 165-2. Fast A/D Converter Locator

Refer to Figure 165-2. Set this jumper to one of the following positions:

- o Position A

  This position is used only with Burst Scan Mode. Channels 0 (HI) and 20 (LO) and the associated COMMON are used for external trigger input and output and are not available as measurement inputs. Also, at least one XTRIGTYPE must be selected (using the DEF BSCAN command).

  Error 55 is returned if a measurement definition is then attempted on either channel. If either channel is already defined, XTRIGTYPE cannot be selected, and error 50 is returned.

- o Position B

  This is the normal position for the jumper, in which channels 0 and 20 are used as measurement inputs. Position B disables external trigger inputs and outputs. If an XTRIGTYPE is specified, error 63 ("Fast A/D is not jumpered for external trigger I/O") is returned.

INSTALLATION

The Fast A/D Converter fits in any of the horizontal slots accessed from the rear of the Front End.

WARNING

ENSURE THAT ALL POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO. PRESS THE POWER SWITCH TO OFF.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

1. Align the Fast A/D Converter in the desired slot so that the board-edge connector is toward the motherboard in the rear of the slot.

2. Push the board straight in until it is mated with the motherboard connectors. Ensure that the two plastic handles snap into position in the chassis.

3. Now wire the signal sources to the appropriate terminals on the input connector. Then plug the connector onto the Fast A/D Converter.

4. Secure the Fast A/D Converter (with attached input connector) to the chassis with the two retaining screws.

INTRODUCTION

The Counter/Totalizer is a six-channel measurement option that supports two functions: event counting and frequency. The assembly is shown in Figure 167-1.

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information for the Counter/Totalizer. Application instructions for the Counter/Totalizer are found in the following sections:

- Section 6D: Frequency Measurement
- Section 6K: Totalizing Measurement

Section 3C provides an installation verification procedure.

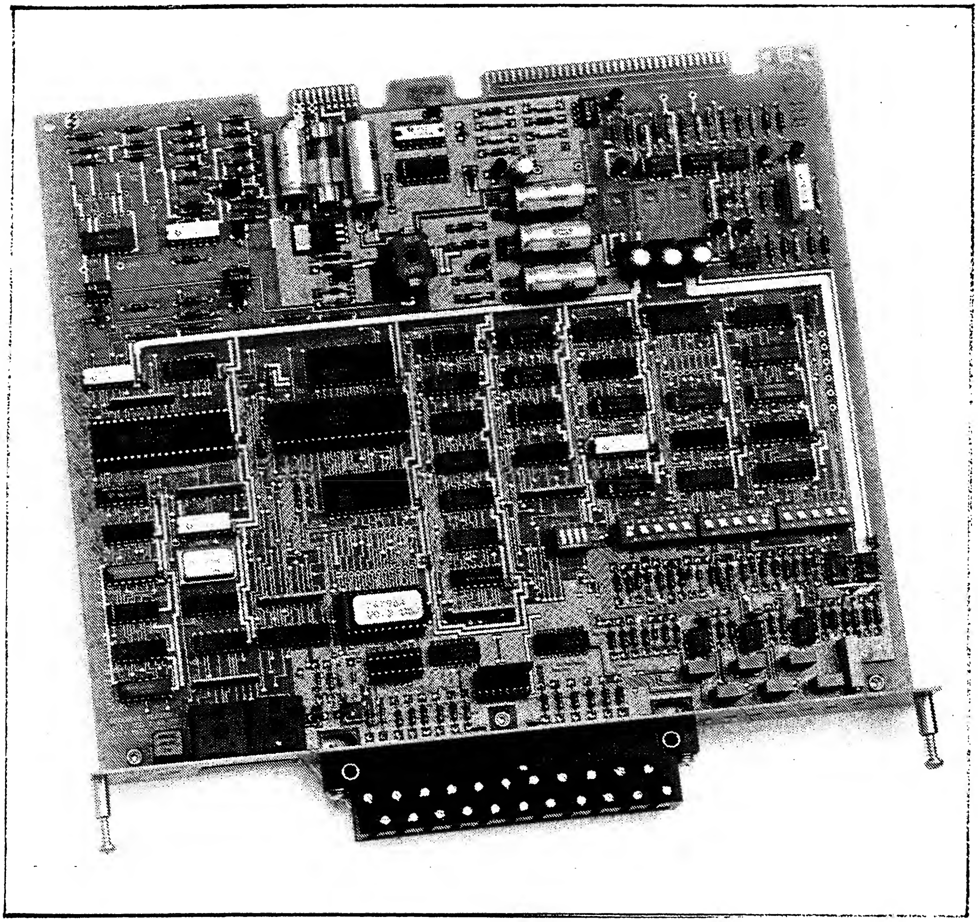


Figure 167-1. Counter/Totalizer Assembly

SPECIFICATIONS

Specifications for the Counter/Totalizer are presented in Section 2. Section 2 also contains system accuracy specifications for frequency and totalizing measurements.

HARDWARE CONFIGURATION

Adjustments

Switches on the Counter/Totalizer assembly select the function of each channel. The assembly also has adjustments that allow it to measure various signal types:

- The reference voltage and input deadband are adjustable. These adjustments define the high and low voltage thresholds of the input.

- Debouncers and input pull-ups allow the Counter/Totalizer to count contact closures.

The intended measurements, either frequency or totalizing, determine the adjustments needed on the Counter/Totalizer assembly. The setup instructions are found in Sections 6D and 6K. Refer to these sections to make the necessary adjustments during installation of the assembly.

Addressing

The channel decade switches on the Counter/Totalizer determine the channel numbers assigned to the assembly. The switches are accessible through the Counter/Totalizer rear panel. The channel decade switches select the channel numbers as shown in the following example:

ADDRESS SWITCH SETTING 100's	10's	CHANNELS ASSIGNED
0	0	0 - 5
0	1	10 - 15
0	2	20 - 25
0	3	30 - 35
.		
.		
9	9	990 - 995

Note that positions 10 through 15 of the hundreds switch are not allowed. If the hundreds switch is set to one of these positions, the assembly will not respond to any commands.

INSTALLATION

Physical Installation

The Counter/Totalizer can be installed in either the Front End mainframe or the 2281A Extender Chassis.

WARNING

ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Press the POWER switch to OFF. If the Counter/Totalizer is being installed in a 2281A, verify that the POWER indicator is off.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

2. Align the assembly with one of the slots in the back of the instrument. Orient the assembly with the component side up.

3. Slide the assembly into the chassis and press firmly until it is seated in the connectors. Secure the assembly in the chassis using the two rear panel retaining screws.

External Connections

The individual channels on the Counter/Totalizer assembly are not electrically isolated from each other. However, the entire card is isolated from chassis ground.

WARNING

ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. With line power disconnected and the POWER switch set to OFF, locate the 22-pin screw terminal connector on the Counter/Totalizer at the rear panel of the instrument.

2. Remove the two retaining screws that hold the connector to the rear panel. Remove the connector from the Counter/Totalizer assembly.

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

3. Each channel requires two connections, INPUT and RETURN. The terminal assignments for each channel are listed on the Counter/Totalizer rear panel. The THRESHOLD OUT and VAR REF VOLT OUT terminals are used to adjust the input threshold voltages. Refer to Sections 6D and 6K for instructions on setting the threshold levels for frequency and totalizing measurements.

CAUTION

Since individual channels are not isolated from each other, all RETURN terminals are connected together on the Counter/Totalizer assembly. All RETURN wires must be at the same voltage.

4. For each terminal, loosen the appropriate screw, insert the external wire into the connector, and tighten the screw until the wire is secured.

5. Install the wired connector on the Counter/Totalizer assembly, and secure the connector to the rear panel with the two retaining screws.

INTRODUCTION

The Digital Input/Output Board allows for information exchange with a digital peripheral device. The four types of exchange are:

- Status Output

  Use the Status Output Connector with the Digital I/O Board. Refer to the -169 subsection.

- Status Input, BCD Input, Binary Input

  A Digital/Status Input Connector (-179) must be configured and used with the Digital I/O Board. Also, for BCD and binary inputs, these digital input devices depend on a handshake procedure to accept data. Refer to the -179 subsection when configuring the Digital/Status Input Connector with the Digital I/O Board.

The Digital I/O Assembly is illustrated in Figure 168-1.

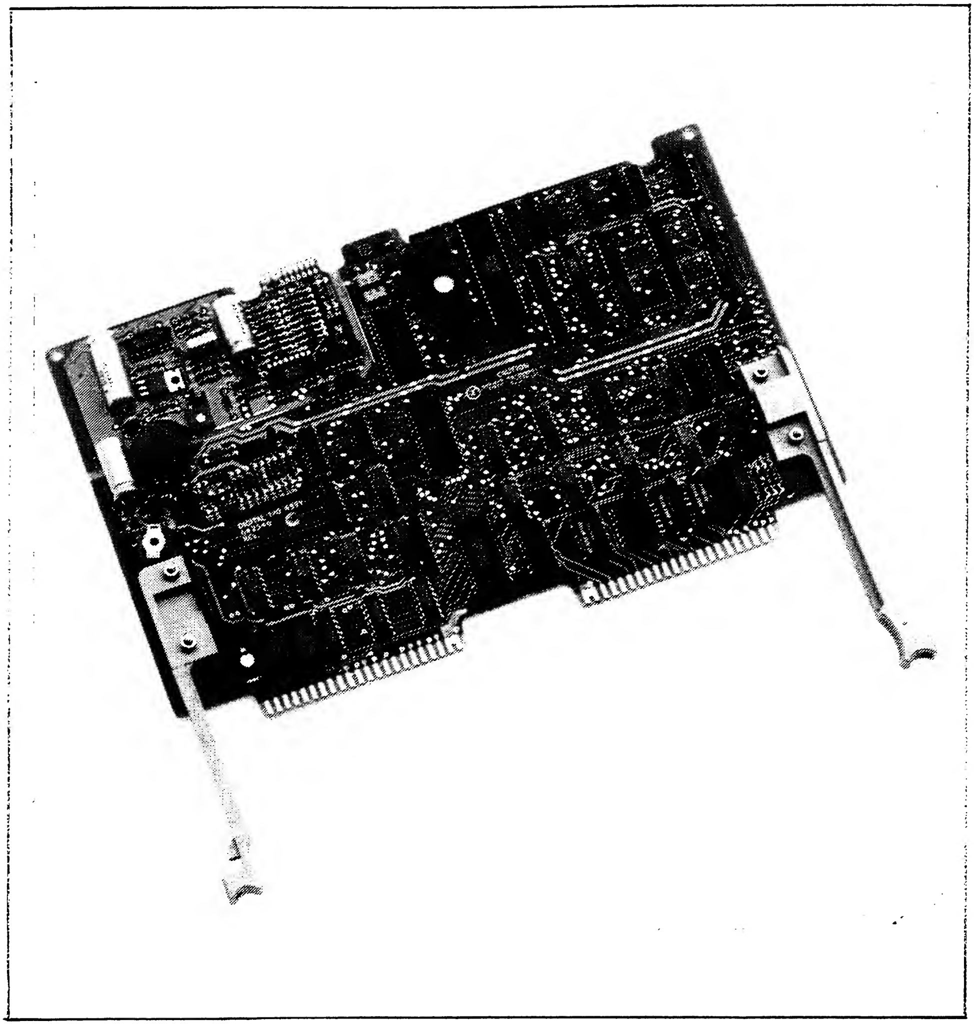


Figure 168-1. Digital I/O Assembly

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Digital I/O Assembly.

Additional information for related option assemblies (Status Output Connector and Digital/Status Input Connector) is presented elsewhere in this manual. Related functions are described in the following subsections:

- Section 6C: Digital/Status Input

- Section 6F: Status Output

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Digital I/O Assembly are presented in Section 2.

HARDWARE CONFIGURATION

Addressing

Each Digital I/O Board must be assigned a unique numeric address. The numeric address is derived from the first channel number within the associated channel block. Dividing this channel number by 10 yields the numeric address. For example, for the channel block beginning with channel 200, the first channel (200) divided by 10 is 20 (the address).

Use the following procedure:

1. With line power disconnected, locate the address switches in the rear left corner of the Digital I/O Board.

2. Access the address switches by removing the Input (or Output) Connector from the Digital I/O Board.

3. Position the address switches to the desired numeric address setting. An appropriate setting corresponds to the block of channels being used.

Addressing depends on channel use as Status I/O or Digital Input. The following paragraphs define the differences.

STATUS I/O

Status input/output addresses each specify a block of 20 channels. For maximum utilization of available channels, only even addresses should be used. The use of odd addresses results in fewer available channels.

ADDRESS	CHANNEL BLOCK
0 0	0 - 19
0 2	20 - 39
0 4	40 - 59
0 6	60 - 79
0 8	80 - 99
1 0	100 - 119
1 2	120 - 139
.	.
.	.
9 8	980 - 999

DIGITAL INPUT

Although each Digital I/O Assembly occupies space for 10 channels, it can support only one digital (BCD or binary) input. As required by the addressing scheme, this input can be addressed as 0 or 10 or any multiple of 10. Some examples:

ADDRESS	CHANNEL
0 0	0
0 1	10
0 2	20
.	.
1 1	110
9 9	990

Communication Format

As shown above, each Digital I/O Board supports either 20 channels of status input/output or one channel of binary or BCD input.

If a Digital/Status Input Connector (-179) is used with the Digital I/O Board, jumpers must be installed on the connector to configure the Digital I/O Board as desired. These instructions are presented with the -179 information.

INSTALLATION

The Digital Input/Output Board is installed in any one of the available option I/O slots in the Front End or 2281A Extender Chassis. Install the board as follows:

WARNING

ENSURE THAT ALL LINE POWER TO THE FRONT END OR 2281A EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN EITHER UNIT AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Verify that power is OFF.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

2. From the rear of the instrument, align the Digital I/O board in the desired slot. The board-edge connector must be facing the motherboard.

3. Secure the board in position. Push the board straight in until it is mated with the motherboard connectors. Verify that the plastic retainers snap into place as the connector mates.

INTRODUCTION

The Status Output Connector can send 20 single-bit output signals from the Digital I/O board to external control points or terminals. Each output is individually selectable and can be used either to drive lamps and relays or change logic levels.

The Status Output Connector is mounted to the 44-pin card-edge connector on the left, rear side of the Digital I/O Board. The connector assembly is enclosed in a plastic housing, allowing protection for the terminal connections and strain relief for the external wiring. The Status Output Connector is illustrated in Figure 169-1.

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Status Output Connector. Applications are discussed in:

- Section 6F: Status Output

Section 3C provides an installation verification procedure.

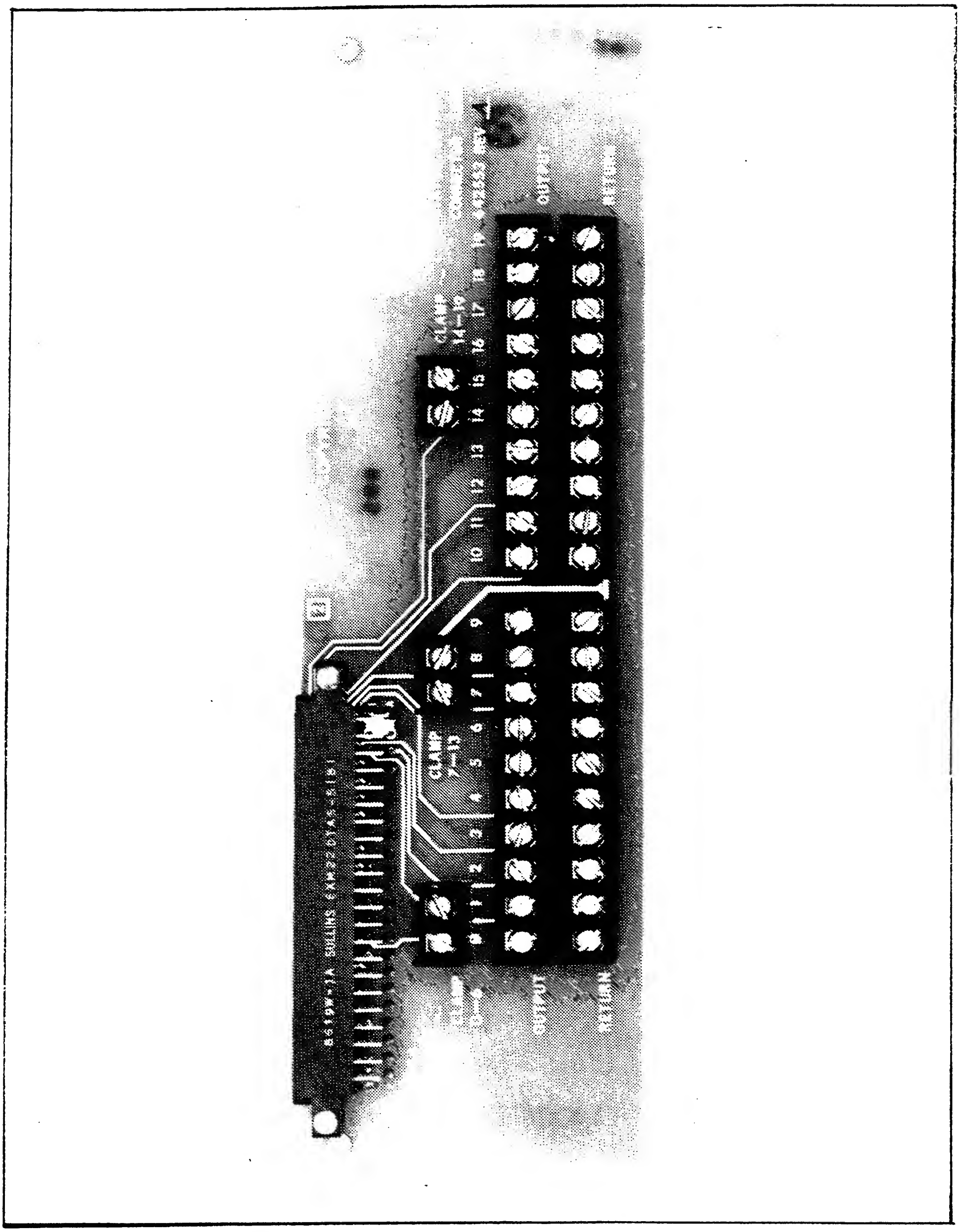


Figure 169-1. Status Output Connector

SPECIFICATIONS

Specifications for the Status Output Connector are presented in Section 2.

REMOVAL AND INSTALLATION

Connections from external control points or terminals to the Front End are made via external wiring to the Status Output Connector. Preparation of the Status Output Connector involves opening the connector housing, connecting the appropriate wiring on the terminals, closing the connector housing, and reconnecting it to the Digital I/O Board. The following steps detail this procedure:

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated I/O Assembly.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set at OFF, locate the connector housing in the rear panel of the Front End.

2. Loosen the two retaining screws that hold the housing to the chassis.

3. Firmly grasp the housing at each end and pull until the enclosed connector block is disconnected from the I/O Assembly.

External Connections

With the connector withdrawn from the Front End or Extender Chassis, perform the following steps:

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

1. Open the housing by pressing each locking tab.

WARNING

SINCE INDIVIDUAL CHANNELS ARE NOT ISOLATED FROM EACH OTHER, ALL RETURN TERMINALS ARE CONNECTED TOGETHER ON THE STATUS OUTPUT CONNECTOR. ALL RETURN WIRES MUST BE AT THE SAME VOLTAGE.

2. The connector is now ready to be wired to external measurement systems. For each connection, loosen the channel terminal screw, attach the external wire to the screw, then tighten the screw until the wire is firmly in place. Notice that the two terminals for each channel are marked OUTPUT and RETURN.

3. Close the housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

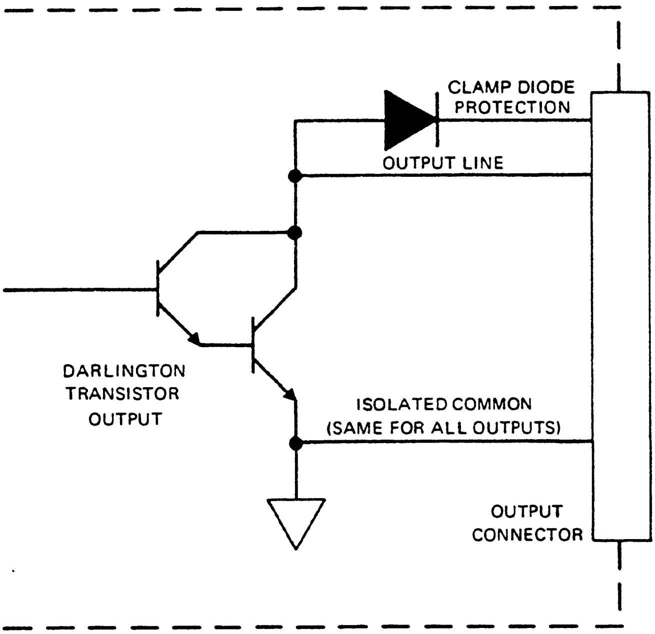
1. With line power disconnected and the POWER switch set at OFF, position the enclosed (and wired) input connector in the guides of the rear panel slot containing the appropriate I/O Assembly.

2. Push the connector onto the card edge connector at the rear of the scanner. Press the connector firmly into place.

3. Attach the connector housing to the chassis with the two retaining screws.

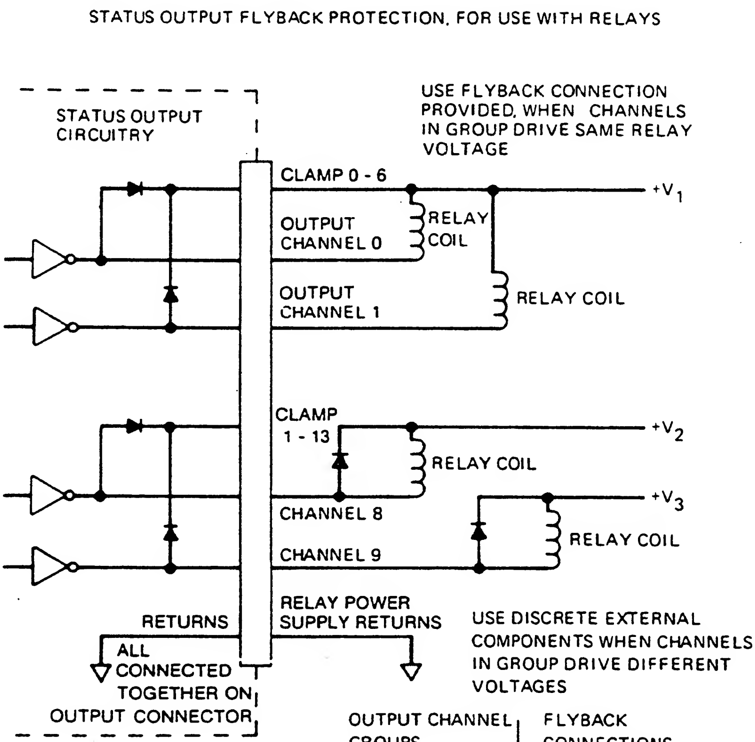
NOTE

If the Digital I/O Board is also being used as a relay driver, the flyback diode terminals on the Status Output Connector must be used to suppress the voltage spike that is generated when the relay coil is shut off. The flyback diodes are connected to different channel blocks on the 20-channel Status Output Connector and are marked: CLAMP 0-6, CLAMP 7-13, and CLAMP 14-19. The 20 output channels may be protected by connecting the proper pin to the coil voltage of the relays being driven. See Figures 169-2 and 169-3. Users wishing to drive relays at varying coil voltages with a single group of channels should provide flyback protection using discrete components.



NOTE:
THE STATUS OUTPUT CANNOT SOURCE CURRENT.
ALL DEVICES ATTACHED TO THE STATUS OUTPUT
MUST BE EXTERNALLY POWERED.

Figure 169-2. Equivalent Circuit for Each Status Output Signal



OUTPUT CHANNEL GROUPS	FLYBACK CONNECTIONS
CH 0 - 6	CLAMP 0 - 6
CH 7 - 13	CLAMP 7 - 13
CH 14 - 19	CLAMP 14 - 19

Figure 169-3. Status Output Flyback Protection

INTRODUCTION

The Analog Output option provides four voltage or current output channels. The Analog Output is shown in Figure 170-1.

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information related to the Analog Output. Related applications are discussed in:

- Section 6A: Analog Output

Section 3C provides an installation verification procedure.

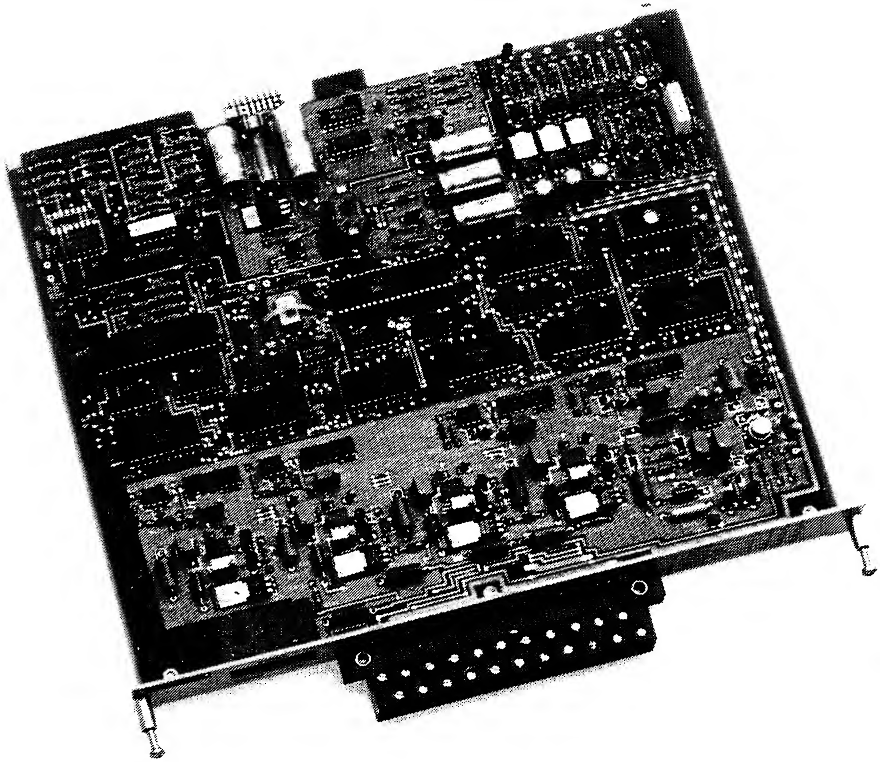


Figure 170-1. Analog Output

SPECIFICATIONS

Specifications for the Analog Output are presented in Section 2.

HARDWARE CONFIGURATION

Address selection sets the channel numbers for each of the four output channels. These switches are accessible through the rear panel of the Analog Output and can be set at any time.

The addressing procedure uses two switches to select the hundreds and tens address for the four channels on the assembly. Table 170-1 further identifies the correspondence between the switch settings and the analog output channel numbers.

Table 170-1. Addressing

ADDRESS SWITCH SETTING		
100's	10's	CHANNELS ASSIGNED
0	0	0 - 3
0	1	10 - 13
0	2	20 - 23
.		
.		
9	9	990 - 993

INSTALLATION

External Connections

The individual channels on an Analog Output are not electrically isolated from each other. However, the entire card is isolated from chassis ground.

Each channel requires two terminal connections. But five screw terminal connections are provided on each of the four output channels. Connecting the correct two terminals on a given channel defines the type of output (current or voltage) for that channel. The three possibilities are:

- Current: 4-20 mA "SOURCE" to "RETURN"
- Unipolar Voltage: VOLTAGE "SOURCE" to "0 TO 10V RTN"
- Bipolar Voltage: VOLTAGE "SOURCE" to "-5 TO +5 V RTN"

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGES COULD OTHERWISE BE ENCOUNTERED.

For each terminal, loosen the appropriate screw, attach the external wire to the screw, then tighten the screw until the wire is firmly in place. Connections are summarized in Table 170-2.

Table 170-2. External Connections

CHANNEL	SIGNAL NAME		TERMINAL NUMBER
0	VOLTAGE	SOURCE	1
		0 TO 10V RTN	2
		-5 TO +5V RTN	3
	4-20 mA	SOURCE	4
		RETURN	5
1	VOLTAGE	SOURCE	6
		0 TO 10V RTN	7
		-5 TO +5V RTN	8
	4-20 mA	SOURCE	9
		RETURN	10
2	VOLTAGE	SOURCE	11
		0 TO 10V RTN	12
		-5 TO +5V RTN	13
	4-20 mA	SOURCE	14
		RETURN	15
3	VOLTAGE	SOURCE	16
		0 TO 10V RTN	17
		-5 TO +5V RTN	18
	4-20 mA	SOURCE	19
		RETURN	20

CAUTION

Although they are independent of each other, each type of return (0 TO 10V RTN, -5 TO +5V RTN, and RETURN) is common among channels. Do not connect different potentials to the same type of return.

Physical Installation

Use the following procedure when installing the Analog Output:

WARNING

ENSURE THAT ALL LINE POWER TO THE FRONT END OR 2281A EXTENDER CHASSIS IS DISCONNECTED BEFORE STARTING THIS PROCEDURE. LETHAL VOLTAGES MAY BE PRESENT WITHIN EITHER UNIT AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

1. Press the POWER switch to OFF. If an Analog Output is being installed in the 2281A, verify that the POWER indicator is off.

CAUTION

Only handle the assembly by the edges, not including the gold fingers. This avoids contaminating the sensitive circuitry with oil from the hands while minimizing the risk of damage by static discharge.

2. Align the Analog Output in the desired slot. The board-edge connector must face in (toward the motherboard).

3. Secure the Analog Output in the slot. Push the board straight in until it makes contact with the motherboard connectors. Then continue pressing firmly until it is mated with these connectors. Now secure the two retaining screws to the chassis.

INTRODUCTION

The Current Input Connector routes a maximum of 20 current input channels to the scanner. The connector consists of an assembly that mounts to the rear 88-pin card-edge connector on the scanner. The connector assembly is enclosed in a plastic housing to protect the terminal connections and provide strain relief for the external wiring. The Current Input Connector is illustrated in Figure 171-1.

Each connector channel uses two screw terminals (HIGH and LOW) and one resistor. The shield is internally connected to LOW (no separate screw terminal is provided for the shield).

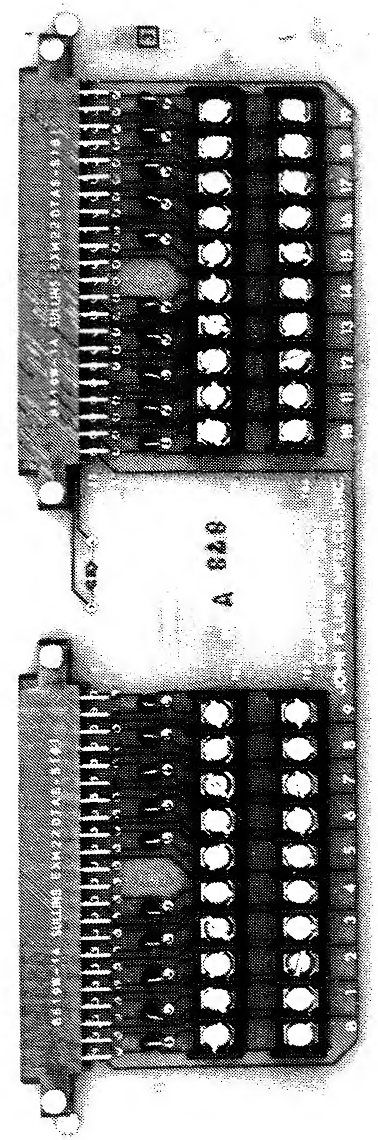


Figure 171-1. Current Input Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Current Input Connector. Applications for the connector are covered in:

- Section 6B: Current Measurement

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Current Input Connector are presented in Section 2. Section 2 also contains system accuracy specifications for current measurement.

REMOVAL AND INSTALLATION

Connections from external current sources to the Front End or Extender Chassis are made via external wiring to the Current Input Connector. Preparation of the Current Input Connector involves opening the connector housing, connecting the appropriate wiring on the terminals, closing the connector housing, and reconnecting it to the Thermocouple/DC Volts Scanner (-162).

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated scanner.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set at OFF, locate the connector housing in the rear panel of the Front End.

2. Loosen the two retaining screws that hold the housing to the chassis.

3. Firmly grasp the housing at each end and pull until the enclosed connector block is disconnected from the scanner.

External Wiring

With the connector withdrawn from the Front End or Extender Chassis, perform the following steps:

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

1. Open the housing by pressing each locking tab.

2. Loosen the each channel terminal screw, attach the external wire to the screw, then tighten the screw. Ensure that current flows into the HI terminal and out of the LO terminal.

3. Close the housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

1. With line power disconnected and the POWER switch set at OFF, position the enclosed (and wired) input connector in the guides of the rear panel slot containing the appropriate scanner.

2. Push the connector onto the card edge connector at the rear of the scanner. Press the connector firmly into place.

3. Attach the connector housing to the chassis with the two retaining screws.

INTRODUCTION

The Transducer Excitation Module (-164) and the Transducer Excitation Connector (-174) provide voltage or current excitation for variable resistance transducers. Multiple functions such as RTD temperature measurement, strain gage measurement, strain-based transducers measurement, and low resistance transducer measurement can thereby be supported.

Measuring the voltage of the stimulated transducer is accomplished either of the following two option configurations:

- The -161 High Performance A/D Converter and the -162 Thermocouple/DC Volts Scanner (-162), with the Voltage Input Connector (-176), the Isothermal Input Connector (-175), or the AC Voltage Input Connector (-160) attached.
- The -165 Fast A/D Converter, with the -176 Voltage Input Connector or the -175 Isothermal Input Connector attached directly.

The Transducer Excitation Connector is illustrated in Figure 174-1.

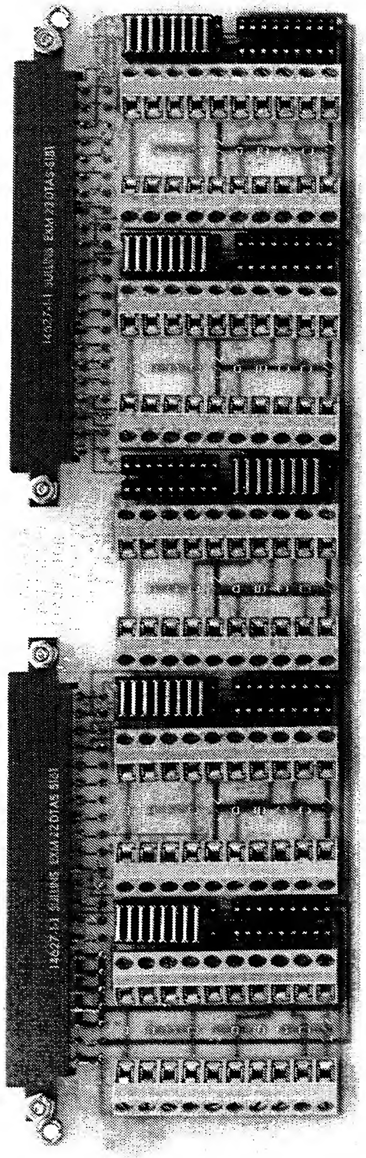


Figure 174-1. Transducer Excitation Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Transducer Excitation Connector.

Where the Transducer Excitation Connector is used in a specific application, the following sections provide more appropriate information. Examples include:

- Section 6E: Resistance Measurement, Configuration B
- Section 6G: Strain Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration B
- Section 6I: Temperature Measurement Using Thermistors

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Transducer Excitation Module (-164) and the Transducer Excitation Connector (-174) are presented in Section 2. Section 2 also contains system accuracy specifications relating use of the module and the connector in providing voltage or current stimulation to various types of measurement transducers. Applicable measurement types include strain, temperature (using RTDs and thermistors), and other resistance measurements.

INSTALLATION

Applications using the Transducer Excitation Module/Connector involve both excitation and measurement connections.

Initially, each group of four channels must be configured for voltage or current excitation by correctly positioning the respective jumper on the Transducer Excitation Connector (-174). Refer to the connector decal for details.

Briefly, installation involves first making external connections to the Transducer Excitation Connector. Interconnections are then made between this connector (which performs the excitation function) and the connector performing the measurement function. Measurement is actually a dc voltage function and can be accomplished with any of the following three input connectors: Voltage Input Connector, Isothermal Input Connector, or AC Voltage Input Connector (dc terminals).

The connector (excitation or measurement) must then be attached to the appropriate option assembly already installed in the Front End. For the excitation function, this is the Transducer Excitation Module. The measurement function uses the Thermocouple/DC Volts Scanner.

Wire Connections

The following procedure describes Transducer Excitation Connector installation on two levels. First, wiring connections are explained. This procedure involves interconnections between the measurement connector (Voltage Input Connector, Isothermal Input Connector, or AC Voltage Input Connector) and the Transducer Excitation Connector. It also requires connections between the Transducer Excitation Connector and the external measurement source.

Once the Transducer Excitation Connector has been wired, it can be installed on the rear of the Transducer Excitation Module. Installation explanations for the measurement connector (Voltage Input Connector, Isothermal Input Connector, or AC Voltage Input Connector) are covered in the appropriate subsection (-176, -175, or -160, respectively).

NOTE

Install the Transducer Excitation Module/Connector directly below the scanner/connector being used for the interconnections. This arrangement allows for maximum ease of installation.

1. Ensure that line power is disconnected and the POWER switch is set to OFF.

2. Open the Transducer Excitation Connector housing by gently pressing each locking tab.

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

3. Familiarize yourself with the connecting terminal arrangement.

    - o Five connecting terminals are available for each channel.

    - o Twenty sets of terminals are provided on each input connector.

4. Wiring between the connectors and from the Transducer Excitation Connector to the external measurement source depends on the type of measurement being made. The figures mentioned below can be found at the end of this subsection.

NOTE

When the -165 Fast A/D Converter is used in conjunction with the Transducer Excitation Connector, make sure both that differential mode is selected and that LOW is jumpered to SHIELD (COMMON) on **ONLY ONE CHANNEL** per a/d converter.

- o Strain measurements must be wired according to Figure 174-2, 174-3, or 174-4 for 1/4-, 1/2-, or full-bridge configurations, respectively.
- o RTD measurements using a 3-wire, constant voltage source must use the wiring shown in Figure 174-5.
- o RTD measurements using a 3-wire, constant current source must use the wiring shown in Figure 174-6.
- o RTD measurements using a 4-wire arrangement must use the wiring shown in Figure 174-7.
- o Each group of four channels must be configured for voltage or current excitation by positioning a jumper on the Transducer Excitation Connector. Refer to the connector decal for details.

5. For each connection, loosen the channel terminal screw, attach the external wire (or jumper) to the screw, then tighten the screw until the wire is firmly in place.

6. For each connector, close the housing and ensure that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

WARNING

BEFORE INSTALLING THE WIRED INPUT CONNECTOR AT THE FRONT END REAR PANEL, ENSURE THAT ALL LINE POWER TO THE MAINFRAME OR EXTENDER CHASSIS IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

Complete the installation by physically installing the connectors as follows:

1. Position the enclosed (and wired) connectors in the guides of the appropriate Front End rear panel slots. Ideally, the Thermocouple/DC Volts Scanner will occupy the slot immediately above that used by the Transducer Excitation Module.

2. Push the connector onto the card edge connection until it is fully engaged.

3. Attach each connector housing to the chassis with the retaining screws.

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

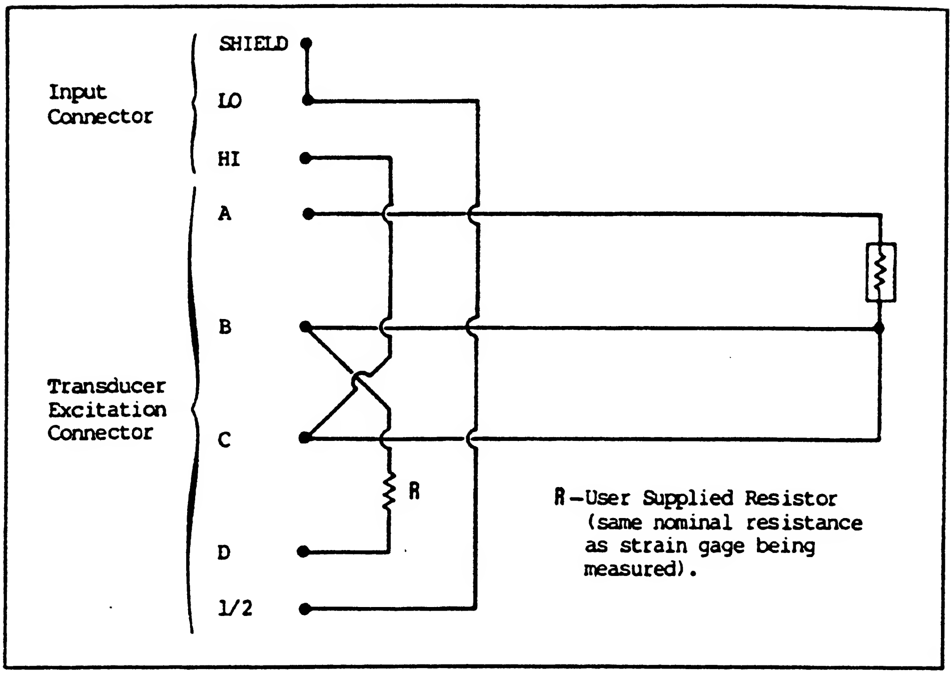


Figure 174-2. Wiring (1/4-Bridge Strain)

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

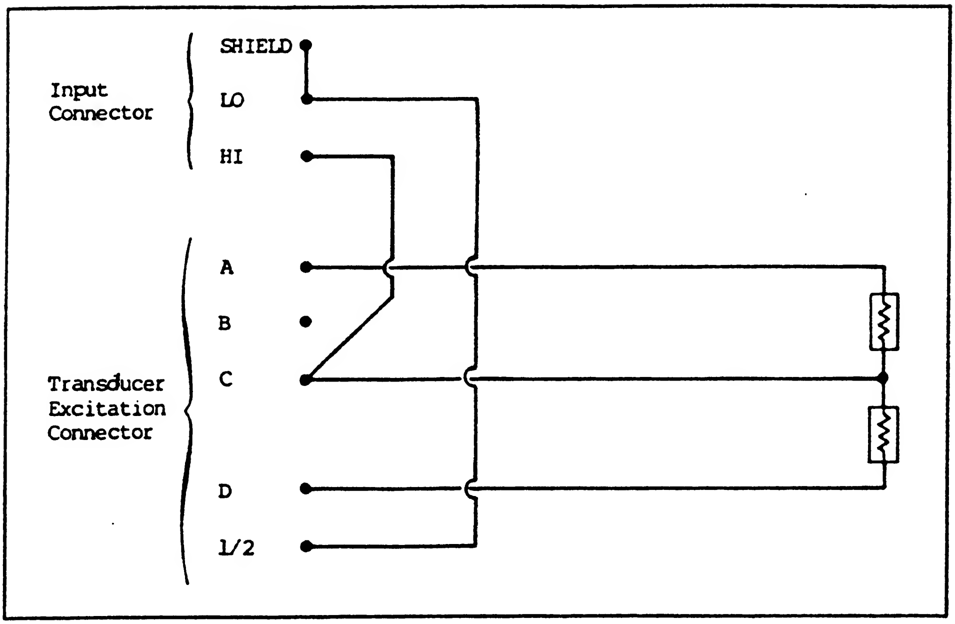


Figure 174-3. Wiring (1/2-Bridge Strain)

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

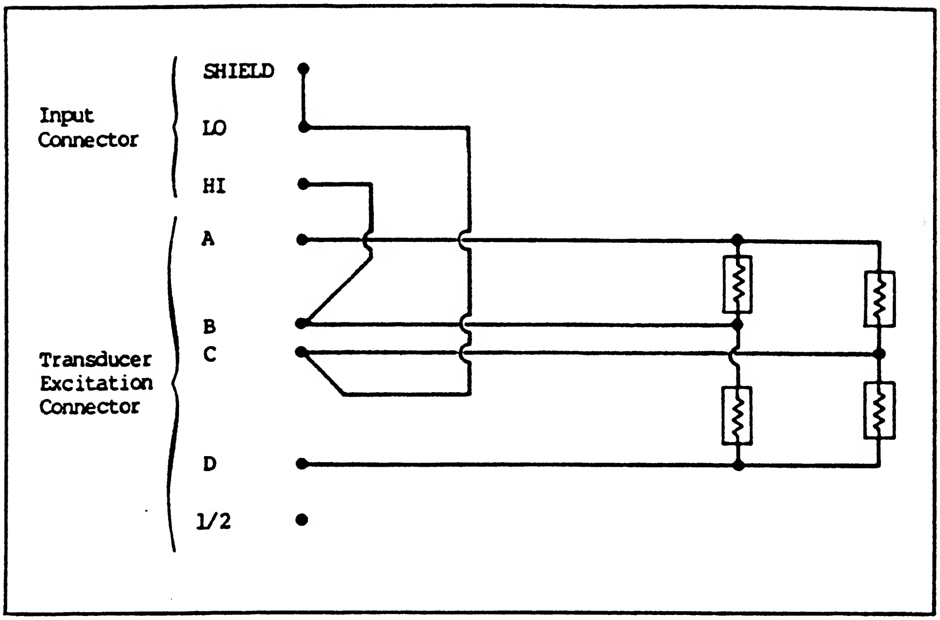


Figure 174-4. Wiring (Full-Bridge Strain)

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

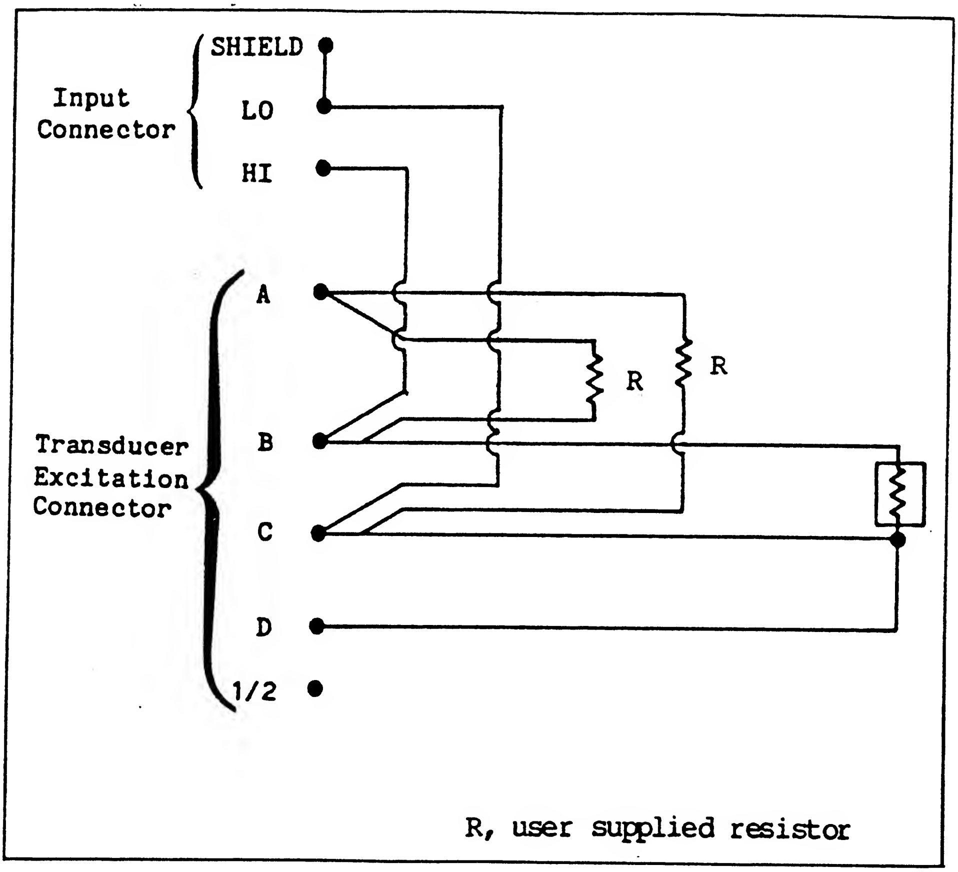


Figure 174-5. Wiring (3-Wire RTD, Constant Voltage)

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

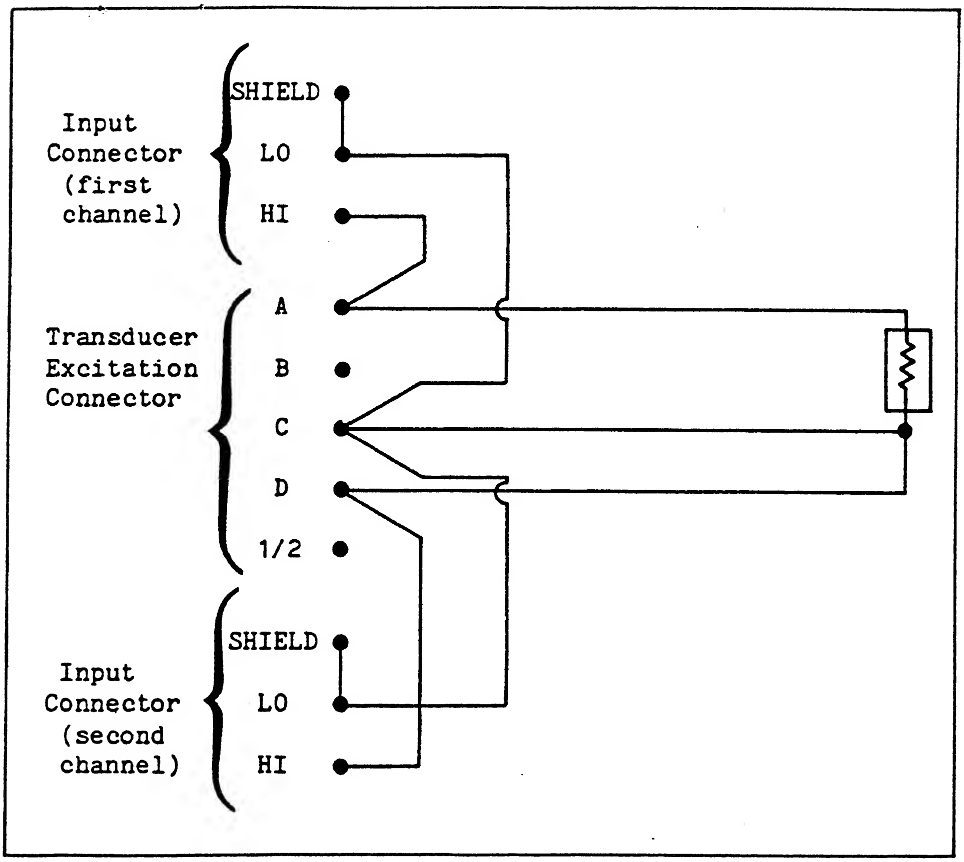


Figure 174-6. Wiring (3-Wire RTD, Constant Current)

NOTE

On the input connector, tie LO to SHIELD on each channel when the -161 High Performance A/D Converter and -162 Thermocouple/DC Volts Scanner are used. If the input connector is used directly on the -165 Fast A/D Converter, tie LO to SHIELD on one channel only (per a/d converter.)

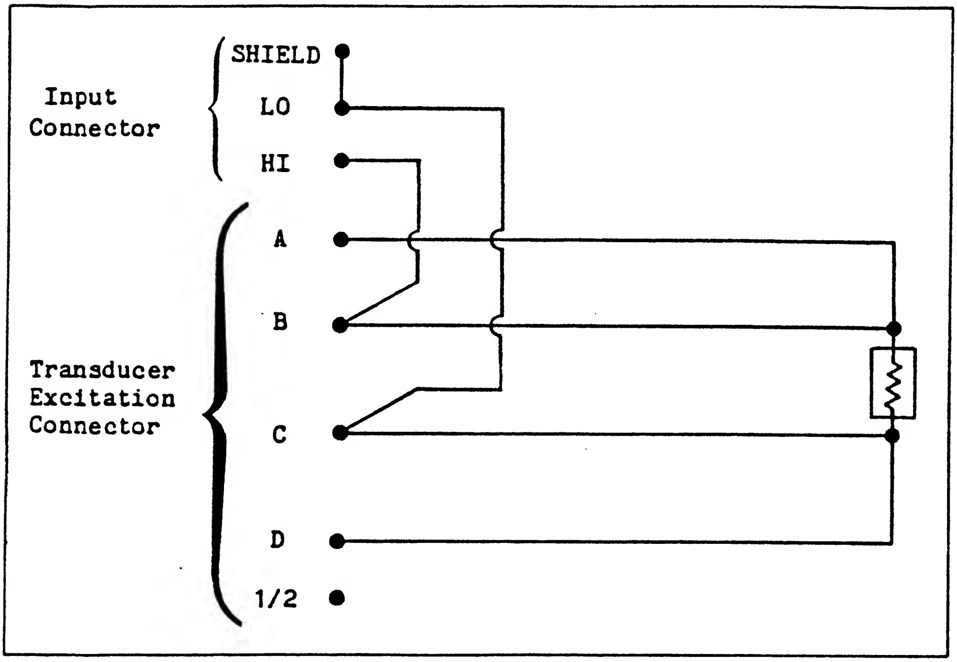


Figure 174-7. Wiring (4-Wire RTD, Constant Current)

INTRODUCTION

The Isothermal Input Connector can be attached either to the -162 Thermocouple/DC Volts Scanner for use with the -161 High Performance A/D Converter or directly to the -165 Fast A/D Converter. The following input channel configurations are possible:

- -162 Scanner/-161 A/D Converter
  A maximum of 20 thermocouple or voltage input channels are routed to the scanner. The connector attaches to the 88-pin edge connector at the rear of the scanner card.

- -165 A/D Converter
  A maximum of 20 differential input channel pairs or 40 single-ended input channels can be routed to the a/d converter. The connector attaches to the 88-pin edge connector at the rear of the a/d converter.

The Isothermal Input Connector is illustrated in Figure 175-1.

The connector assembly is enclosed in a plastic housing. This arrangement provides protection for the terminal connections and strain relief for the external wiring. Retaining screws secure the housing to the scanner chassis.

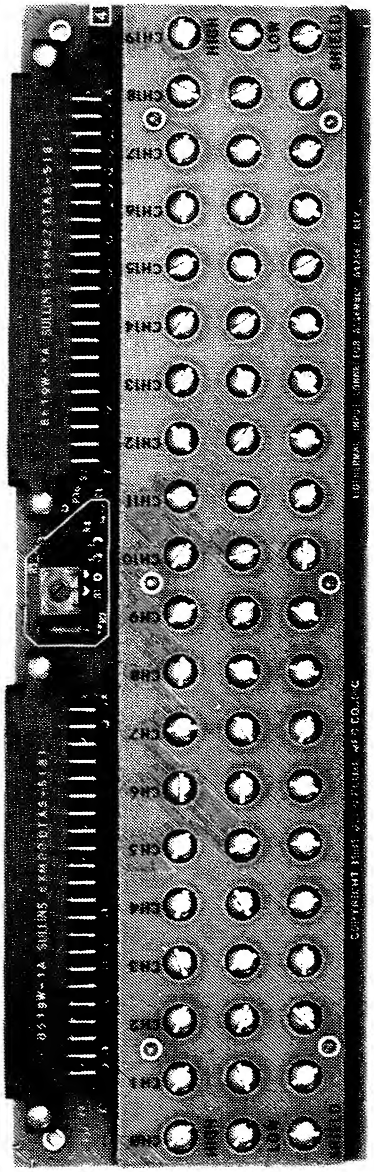


Figure 175-1. Isothermal Input Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Isothermal Input Connector.

Other sections provide information related to specific applications. These include:

- Section 6J: Temperature Measurement Using Thermocouples.

- Other measurement functions use the dc voltage measurement capabilities of the Isothermal Input Connector. These include

  - Section 6H: Temperature Measurement Using RTDs, Configuration B
  - Section 6M: Voltage Measurement - DC
  - Section 6G: Strain Measurement
  - Section 6E: Resistance Measurement, Configuration B

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Isothermal Input Connector are presented in Section 2. Section 2 also contains system accuracy specifications for the types of measurements supported by this connector (thermocouple temperature measurements and dc voltage measurements).

REMOVAL AND INSTALLATION

Connections from external measurement sources to the Front End are made via wiring to the input connector block. Installation of the Isothermal Connector involves assembling and connecting the wires to the terminals, and attaching the connector to the appropriate scanner.

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated scanner.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set at OFF, locate the connector housing in the rear panel of the Front End.

2. Loosen the two retaining screws that hold the housing to the chassis.

3. Firmly grasp the housing at each end and pull until the enclosed connector block is disconnected from either the scanner (if used with the -161 High Performance A/D Converter) or the -165 Fast A/D Converter.

Shielding Considerations (-161/-162 Configuration)

The following shield considerations pertain to -175 connector use with the -162 scanner and -161 a/d converter.

Any a/d converter exhibits some parasitic capacitance to ground. When the common mode voltage on the a/d converter changes (due to channel switching or the presence of ac voltages), current flows through this capacitance, causing reading errors and/or noise. The SHIELD connection on the input connector provides a means to minimize these effects.

With the High Performance A/D Converter and its shield tracking the same voltage, current in the HI and LOW leads is minimized. Note that HI, LOW and Shield are fully isolated from ground and are capable of being safely floated to 250 volts above ground.

Use the following SHIELD guidelines when connecting the Isothermal Input Connector:

1. If significant RFI (Radio Frequency Interference) or EMI (Electro-Magnetic Interference) is present, the best measurement results are obtained by connecting SHIELD to LOW (on the input connector) with the shortest possible path.

2. If significant common mode voltage (greater than one volt) is present, connect SHIELD to LOW by means of a third wire at the measurement point. This arrangement is shown in Figure 175-2.

3. Never tie SHIELD to HI. This may actually amplify the effects of noise on the signal, causing a degradation in measurement performance.

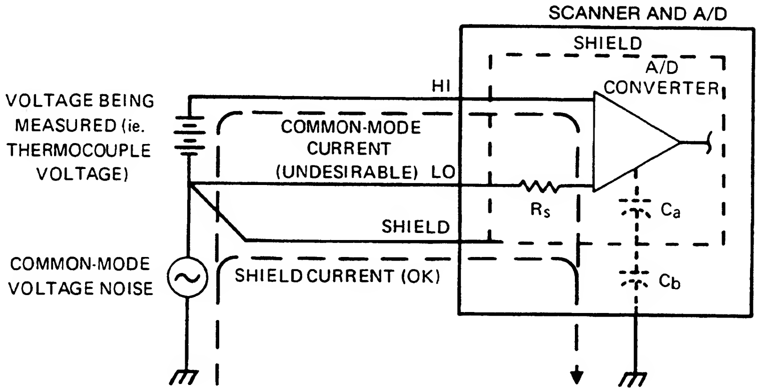


Figure 175-2. Shield Connection for Optimum Common Mode Rejection (-161/-162 Configuration)

4. Never leave SHIELD unconnected. Static charge buildup may cause the maximum SHIELD to LOW voltage to be exceeded, resulting in instrument damage.

5. Never connect SHIELD to earth ground unless the LOW terminal is also grounded. This results in greatly increased common mode currents due to the large value of capacitance between the Shield and the A/D Converter.

Shield Considerations (-165 Configuration)

The following shield considerations pertain to -175 connector use directly with the -165 A/D Converter.

All SHIELD (Common) terminals on the input connector are tied together on the Fast A/D Converter. Therefore, it is only necessary to connect one of the 20 COMMON terminals to a level that is within ±10V of the signals to be measured. Refer to Figure 175-3 for terminal layout information.

NOTE

If induced power line noise is a factor on some of the signals, use differential connections for quieter measurements.

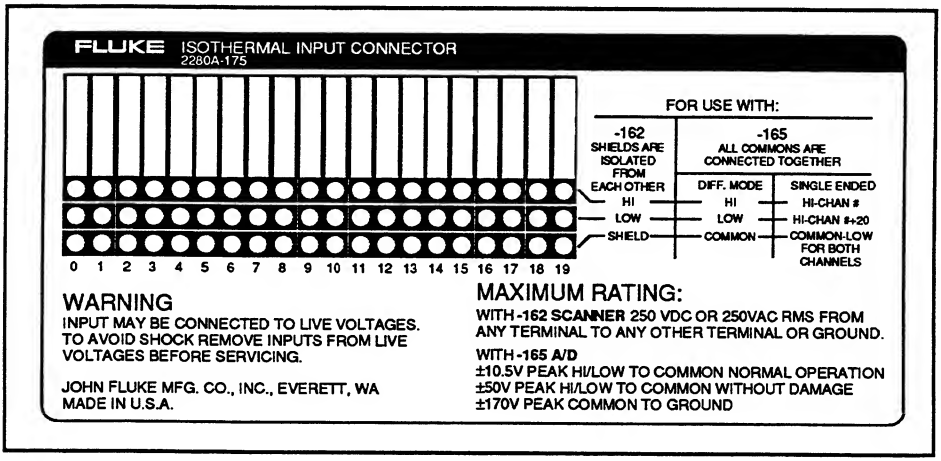


Figure 175-3. Input Terminals

Following are guidelines for connecting the common terminals when using the Isothermal Input Connector with the Fast A/D Converter.

- Differential Inputs

  When connecting differential inputs to HI and LO terminals, make sure that one of the COMMON (SHIELD) terminals on the connector is attached to a level that is within $\pm$10V of HI and LO.

- Single-Ended Inputs

  Remember that all COMMON terminals are connected together on the a/d converter; these terminals cannot be connected to signals that are at different voltages. However, if all signal sources are isolated from ground, single-ended inputs can be used, allowing for 40 inputs per a/d converter.

Thermocouple Connections

The Isothermal Input Connector is now ready to be wired to the external thermocouples. For each connection, loosen the channel terminal screw, attach the external wire to the screw, then tighten the screw until the wire is firmly in place. Notice that the three terminals for each channel are marked HIGH, LOW, and SHIELD. Starting at Channel 0, attach the external wiring for the desired application.

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

NOTE

For proper reading polarity, ensure that the red lead is always connected to LO and the remaining lead is always connected HIGH.

Close the housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

Complete the Isothermal Input Connector installation:

1. Position the assembled input connector in the guides of the Front End rear panel slot containing the appropriate scanner (if used with the -161 High Performance A/D Converter) or -165 Fast A/D Converter.

2. Push the connector firmly into place on the card edge connector at the rear of the scanner or -165 a/d converter.

3. Attach the connector housing to the chassis with the two retaining screws.

INTRODUCTION

The Voltage Input Connector can be attached either to the -162 Thermocouple/DC Volts Scanner for use with the -161 High Performance A/D Converter or directly to the -165 Fast A/D Converter.

- -162 Scanner/-161 A/D Converter
  A maximum of 20 voltage input channels are routed to the scanner. The connector attaches to the 88-pin edge connector at the rear of the scanner card.

- -165 A/D Converter
  A maximum of 20 differential input channel pairs or 40 single-ended input channels can be routed to the a/d converter. The connector attaches to the 88-pin edge connector at the rear of the a/d converter.

The connector assembly is enclosed in a plastic connector housing both for protection of the terminal connections and strain relief for the external wiring. Retaining screws attach this housing to the chassis. Each Input Connector channel uses three screw terminals (HIGH, LOW, and SHIELD).

The Voltage Input Connector is illustrated in Figure 176-1.

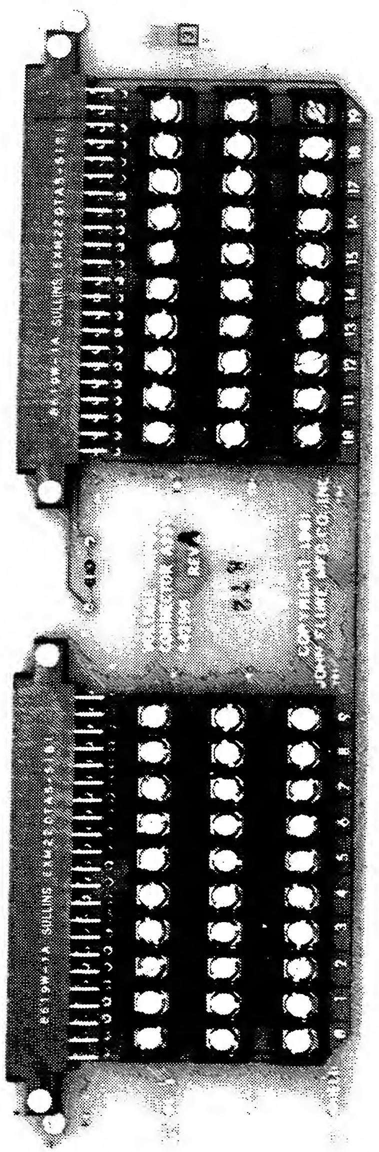


Figure 176-1. Voltage Input Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Voltage Input Connector. Where the Voltage Input Connector is used in a specific measurement function, other sections of the this manual provide more appropriate information. Examples include:

- Section 6E: Resistance Measurement, Configuration B
- Section 6G: Strain Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration B
- Section 6I: Temperature Measurement Using Thermistors, Configuration B
- Section 6M: Voltage Measurement - DC

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the Voltage Input Connector are presented in Section 2. Section 2 also contains system accuracy specifications for dc voltage measurement.

REMOVAL AND INSTALLATION

External measurement sources are connected to the Front End via wiring to the input connector block. Installation of the Voltage Input Connector involves assembling and connecting wiring to the terminals and attaching the connector to the appropriate scanner.

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated scanner.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set at OFF, locate the connector housing in the rear panel of the Front End.

2. Loosen the two retaining screws that hold the housing to the chassis.

3. Firmly grasp the housing at each end and pull until the enclosed connector block is disconnected from the scanner.

Shielding Considerations (-161/-162 Configuration)

The following shield considerations pertain to -176 connector use with the -162 scanner and -161 a/d converter.

Any a/d converter exhibits some parasitic capacitance to ground. When the common mode voltage on the a/d converter changes (due to channel switching or the presence of ac voltages), current flows through this capacitance, causing reading errors and/or noise. The SHIELD connection on the input connector provides a means to minimize these effects.

With the High Performance A/D Converter and its shield tracking the same voltage, current in the HI and LOW leads is minimized. Note that HI, LOW and Shield are fully isolated from ground and are capable of being safely floated to 250 volts above ground.

Use the following guidelines when connecting the Voltage Input Connector:

1. If significant RFI (Radio Frequency Interference) or EMI (Electro-Magnetic Interference) is present, the best measurement results are obtained by connecting SHIELD to LOW (on the input connector) with the shortest possible path.

2. If significant common mode voltage (greater than one volt) is present, connect SHIELD to LOW by means of a third wire at the measurement point. This arrangement is shown in Figure 176-2.

3. Never tie SHIELD to HI. This may actually amplify the effects of noise on the signal, causing a degradation in measurement performance.

4. Never leave SHIELD unconnected. Static charge buildup may cause the maximum SHIELD to LOW voltage to be exceeded, resulting in instrument damage.

5. Never connect SHIELD to earth ground unless the LOW terminal is also grounded. This results in greatly increased common mode currents due to the large value of capacitance between the Shield and the A/D Converter.

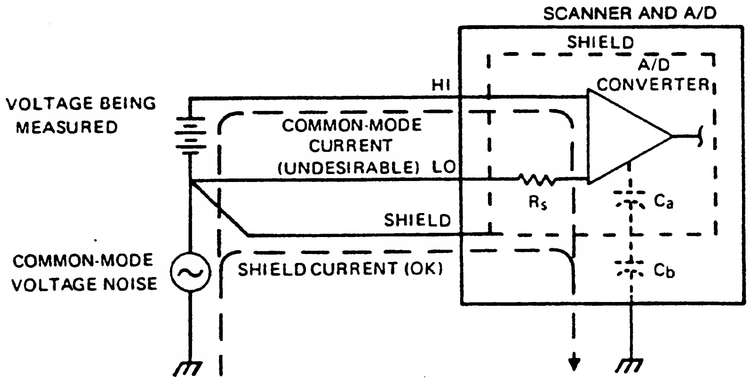


Figure 176-2. Shield Connection for Optimum Common Mode Rejection (-162/-161 Configuration)

Shield Considerations (-165 Configuration)

The following shield considerations pertain to -176 connector use directly with the -165 A/D Converter.

All SHIELD (COMMON) terminals on the input connector are tied together on the Fast A/D Converter. Therefore, it is only necessary to connect at least one of the 20 COMMON terminals to a level that is within $\pm$10V of the signals to be measured. Refer to Figure 176-3 for an overview of the input terminals.

NOTE

If induced power line noise is a factor on some of the signals, use differential connections for quieter measurements.

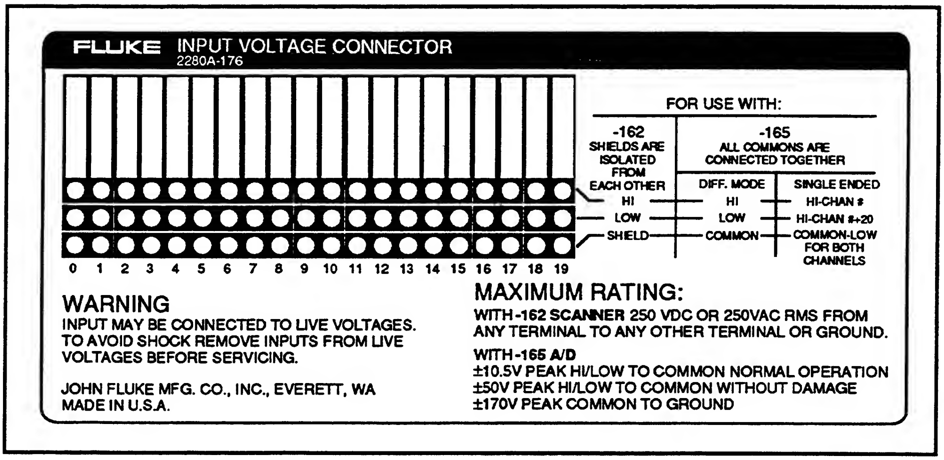


Figure 176-3. Input Terminals

Following are guidelines for connecting the common terminals when using the Voltage Input Connector with the Fast A/D Converter.

- o Differential Inputs

  When connecting differential inputs to HI and LO terminals, make sure that one of the COMMON (SHIELD) terminals is connected to a level that is within $\pm$10V of HI and LO.

- o Single-Ended Inputs

  Remember that all COMMON terminals are connected together on the a/d converter; these terminals cannot be connected to signals that are at different voltages.

External Wire Connections

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

The Voltage Input Connector is now ready to be wired to external measurement systems. Proceed as follows:

1. For each connection, loosen the channel terminal screw, attach the external wire to the screw, then tighten the screw until the wire is firmly in place.

2. Notice that the three terminals for each channel are marked HIGH, LOW, and SHIELD. Starting at Channel 0, attach the external wiring for the desired application. Observe proper polarity.

3. Close the housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

Complete the Voltage Input Connector Installation:

1. Position the enclosed (and wired) input connector in the guides of the Front End rear panel slot containing either the appropriate scanner (if used with the -161 High Performance A/D Converter) or the -165 A/D Converter.

2. Push the connector firmly into place on the card-edge connector at the rear of either the scanner or the -165 A/D Converter.

3. Attach the connector housing to the chassis with the two retaining screws.

INTRODUCTION

The RTD/Resistance Input Connector provides 20 sets of connection points for wiring external resistance transducers to the RTD/Resistance Scanner. The RTD/Resistance Input Connector is illustrated in Figure 177-1.

Each of the 20 channels of terminals provides five termination points for accommodating 4-Wire, 3-Wire, and 2-Wire lead wire measurement configurations. The use of a 3mm (1/8 in) standard blade screwdriver is required for fastening the lead wires in the terminal blocks.

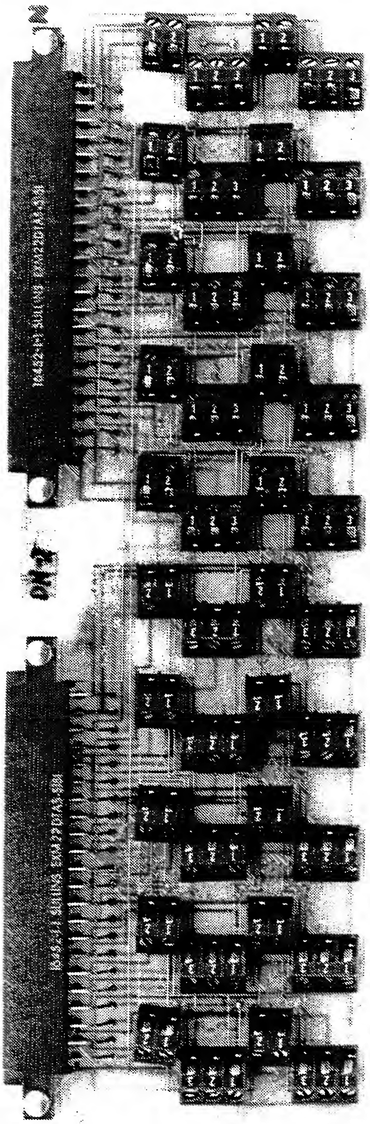


Figure 177-1. RTD/Resistance Input Connector

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information directly related to the use of the RTD/Resistance Input Connector with the RTD/Resistance Scanner.

Other sections in this manual provide more detailed information when the RTD/Resistance Connector is used to implement a specific measurement function. These sections are:

- Section 6E: Resistance Measurement
- Section 6H: Temperature Measurement Using RTDs, Configuration A

Section 3C provides an installation verification procedure.

SPECIFICATIONS

Specifications for the RTD/Resistance Input Connector are presented in Section 2. Section 2 also contains system accuracy specifications for each type of measurement supported by the RTD/Resistance Scanner/Connector. These include temperature (using RTDs) and resistance measurements.

REMOVAL AND INSTALLATION

External resistance sensors are connected to the Front End through the RTD/Resistance Input Connector. Installation of this connector involves assembling and connecting the sensor lead wires to the connector terminals and attaching the connector to the RTD/Resistance Scanner.

WARNING

BEFORE REMOVING OR INSTALLING THE CONNECTOR, ENSURE THAT ALL LINE POWER TO THE FRONT END IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated scanner.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With Front End line power disconnected and the POWER switch set at OFF, locate the horizontal connector housing in the back.

2. Loosen the two retaining screws that hold the housing to the chassis.

3. Firmly grasp the housing at both ends and pull until the enclosed connector block is disconnected from the scanner.

4. Open the housing by gently pressing each locking tab.

External Wiring Connections

WARNING

BE SURE THAT THE WIRES BEING CONNECTED ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE EXTERNAL CIRCUIT CONNECTED TO THESE WIRES IS NOT ENERGIZED. LETHAL VOLTAGES COULD OTHERWISE BE ENCOUNTERED.

The RTD/Resistance Input Connector can now be wired to external resistance sensors. Proceed as follows:

1. Familiarize yourself with the arrangement of the connecting terminals.

   - Five connecting terminals are available for each channel.

   - Twenty sets of terminals are provided on each input connector.

   - Wiring for each set of terminals is defined by the 4-Wire (4W), 3-Wire Accurate (3WA), or 3-Wire with Common Mode (3-Wire Isolated) (3WCM) measurement mode selected on the associated RTD/Resistance Scanner.

   - Where lead wire resistance errors are negligible, 2-Wire connections can be used when the Scanner is set for 4-Wire operation.

   - Refer to the following Figures 177-2 through 177-5. The connector housing decal is also a good reference source.

2. For each connection, loosen the terminal block screw with a 3mm standard blade screwdriver, place the stripped end of the external wire or jumper inside the terminal block opening, and tighten the screw until the wire is firmly clamped in place.

NOTE

To form jumpers with and connect all but the largest gauge lead wire, strip about 30mm (1.2in) of insulation from the end of the wire. Place the end in one of the two terminal block openings and clamp it in. Form a sharp "U" in the lead wire approximately 15mm (0.6in) from the terminal block. Stuff the bottom of the "U" in the second terminal block opening and clamp it in, thereby connecting the lead wire and forming a jumper at the same time.

3. Close the input connector housing, ensuring that the external wires exit the rear of the enclosure without being pinched.

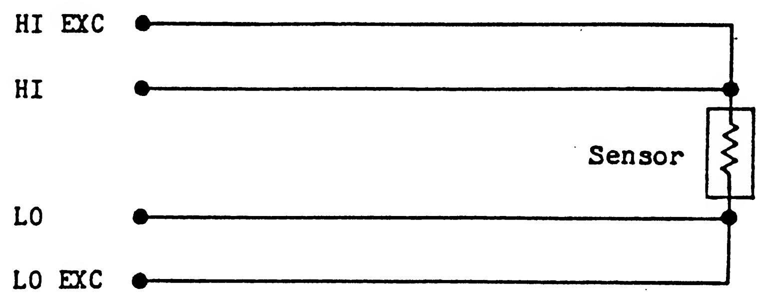
Connector Installation

Complete the connector installation as follows:

1. Position the wired and enclosed input connector in the the Front End rear panel slot containing the RTD/Resistance Scanner.

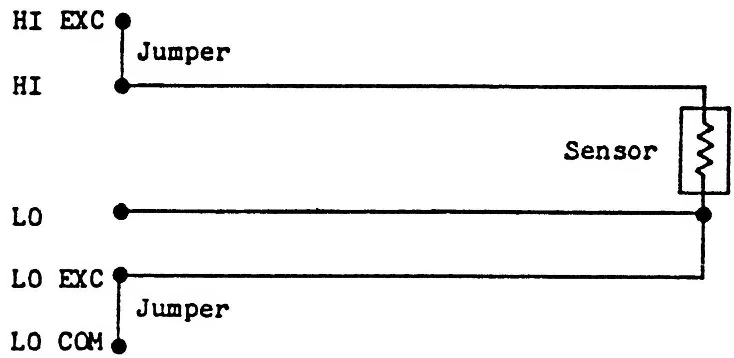
2. Push the input connector firmly into place on the scanner rear card edge.

3. Attach the connector housing to the chassis with the two retaining screws.



This is the most accurate measurement mode.

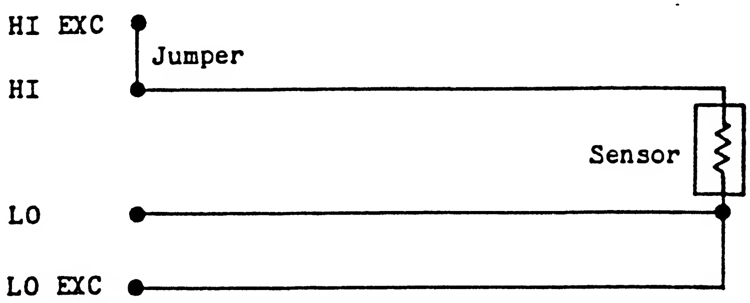
Figure 177-2. 4-Wire Wire Connections



Ensure that the HI and LO EXC lead wires have the same length, composition, and resistance.

Use this 3-Wire configuration if at all possible. Note that the LO COM's of ten channels, (e.g., 0 to 9) are connected together inside the connector pwb.

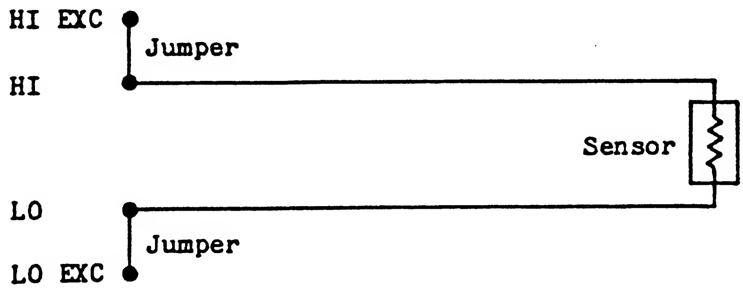
Figure 177-3. 3-Wire Accurate Connections



Ensure that the HI and LO EXC lead wires have the same length, composition, and resistance.

This is much less accurate than the 3WA mode for all but large (high-kilohm) resistance measurements.

Figure 177-4. 3-Wire Isolated Connections



Lead wire resistances must be negligible when compared to the sensor resistance.

Figure 177-5. 2-Wire Connections

INTRODUCTION

The Digital/Status Input Connector can be used for the mutually exclusive functions of providing BCD digital input, binary digital input, or status input information. This assembly connects to the Digital I/O Board (-168). It can be configured by the user.

The Digital/Status Input Connector is illustrated in Figure 179-1.

WHERE TO FIND MORE INFORMATION

This subsection presents general and installation information specifically related to the Digital/Status Input Connector.

Additional information is presented elsewhere in this manual. Specific applications are discussed in:

- Section 6C: Digital/Status Input

Section 3C provides an installation verification procedure.

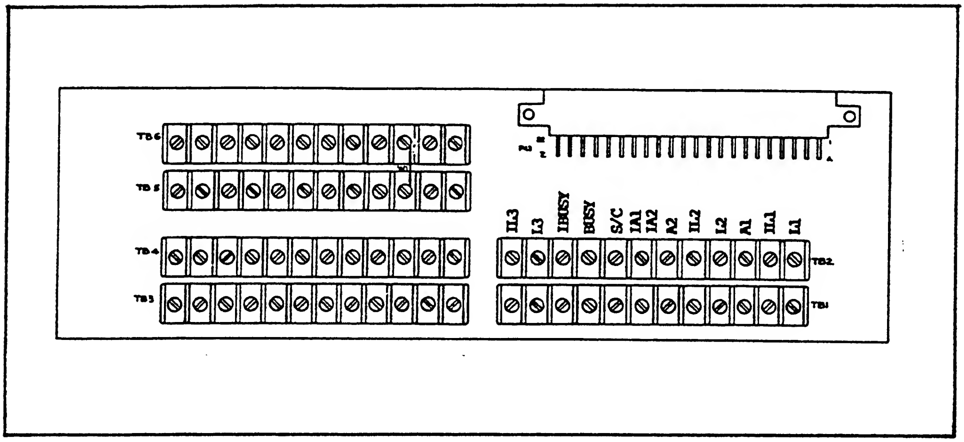


Figure 179-1. Digital/Status Input Connector

SPECIFICATIONS

Specifications for the Digital/Status Input Connector are presented in Section 2.

HARDWARE CONFIGURATION

Each Digital/Status Input Connector must be configured for use with the Digital I/O Board. Also, a handshake procedure must be specified to allow BCD or binary data exchange with external devices.

Input Data Format

Digital input data formats (BCD and Binary) are shown in Figure 179-2. One of the following two data formats can be specified by the user:

- 5-digit BCD (Binary-Coded Decimal that ranges from +/- 79999), with polarity sign
- 16-bit Binary Format with sign

The desired format is chosen by configuring inputs 21 and 22 on the Digital/Status Input Connector as follows:

Binary	BCD
Input 21 -- 0	Input 21 -- 1
Input 22 -- 0	Input 22 -- 0

Zero (0) indicates a jumper from the SIGNAL terminal to its RETURN. One (1) indicates no connection.

NOTE

Do not leave both inputs open. Digital I/O Board operation is undefined if the inputs are open.

Digital Input

When configured for digital input, the Digital/Status Input Connector allows the Digital I/O Board to accept parallel digital data from an external source. This data is received at the channel address set on the associated Digital I/O Board.

One of three data input handshake methods must be used to properly interface the connector with digital input data. The three methods are illustrated in Figure 179-3. Although any one handshake method acts independently of the other two, the functions performed by each are identical. Note that a data input handshake process is used for BCD or Binary input configurations only.

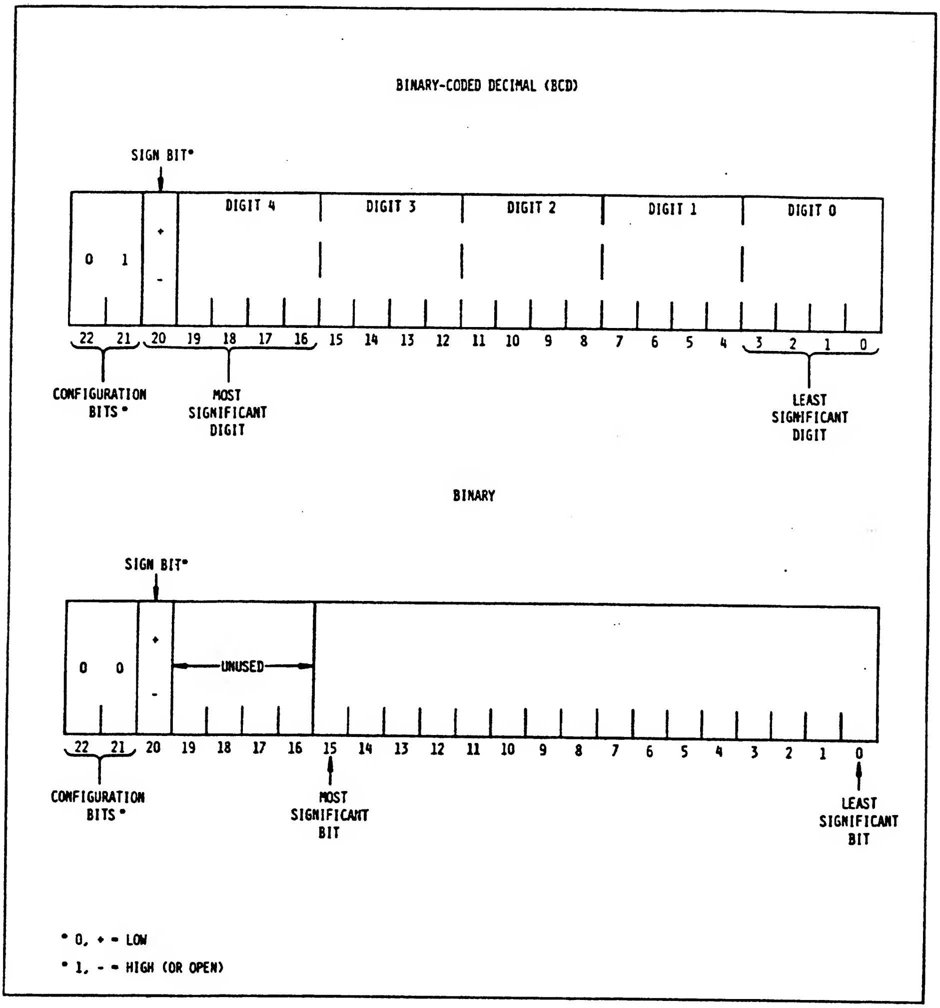


Figure 179-2. Digital Input Data Formats

Select the desired method by connecting the external device to the proper handshake terminals on the Digital/Status Input Connector. These terminals are located on the right side of the assembly, directly below the connector pins. Refer to Figure 179-3 for the location of the proper handshake terminals. Terminal abbreviations are summarized in Table 179-1. Also note the following:

- Unless otherwise specified, all control signals are active (1) in HIGH logic state. Each signal may be set to zero by connecting it to its RETURN terminal or by driving it to a logic low level with respect to the RETURN.

- The load inputs (L1, L2, L3, IL1, IL2, IL3) are sampled inputs with 12.5 us minimum pulse duration.

- The load inputs L1, L2, and L3 cause data to be loaded when a logic 0 to logic 1 transition occurs. The inverted load inputs IL1, IL2, and IL3 are effective when a high to low transition occurs.

Table 179-1. Handshake Terminal Abbreviations

SYMBOL	NAME	SIGNAL DIRECTION
IL3	Invert LOAD3	Input
L3	LOAD3	Input
IBUSY	Invert BUSY	Input
BUSY	BUSY	Output
S/C	Single/Continuous Control	Input
IA1	Invert Acknowledge 1	Input
IA2	Invert Acknowledge 2	Input
A2	Acknowledge 2 (ACK 2)	Output
IL2	Invert LOAD2	Input
L2	LOAD2 (LOAD 2)	Input
A1	Acknowledge 1 (ACK 1)	Output
IL1	Invert LOAD1	Input
L1	LOAD1 (LOAD 1)	Input

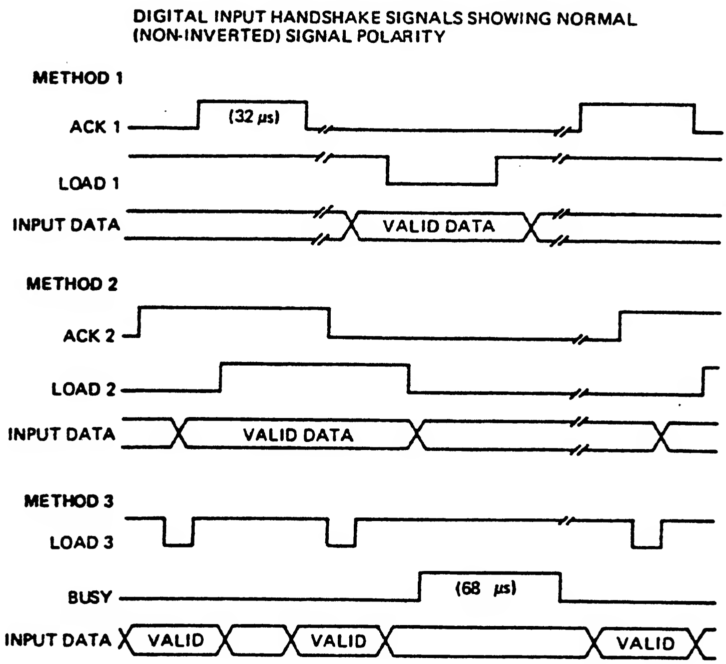


Figure 179-3. Digital Input Handshake Signals Showing Normal (Non-Inverted) Signal Polarity

- The terminals marked S/C on the connector comprise the Single/Continuous control.

  If left unconnected, the S/C control line sets the Digital I/O Board in a continuous input mode. In this mode, the handshake and data loading process are performed repeatedly between input data sampling by the Front End. The Front End reads only the latest data loaded.

  If the S/C SIGNAL terminal is connected to RETURN, the Digital I/O board is placed in a single input mode. In this mode, data may be loaded only once between samplings by the Front End. Once a load has occurred, the handshake process is inhibited until the Front End has retrieved the input data from the Digital I/O Board.

HANDSHAKE METHOD #1

Immediately following power-up, A1 (Acknowledge 1) is asserted (high). A1 is a 17-microsecond pulse generated by the Digital I/O board indicating that data may be loaded. Data is entered by the external device and latched with the L1 (LOAD1) control signal. In the continuous mode, A1 is again asserted after L1 is reset. In the single mode, A1 is inhibited until the input data is sampled by the Front End.

HANDSHAKE METHOD #2

Following power-up, A2 (Acknowledge 2) is asserted by the Digital I/O board. L2 (LOAD2) may then be asserted by the external device to load the data on the input lines. A2 is withdrawn once the data is received. L2 may then be withdrawn. In the continuous mode, A2 is again asserted after L2 becomes low. In the single mode, A2 remains inactive until the Front End has sampled the data. In either case, L2 must be reset low before the cycle may be repeated.

HANDSHAKE METHOD #3

L3 (LOAD3) may be asserted by the external device at any time. In the continuous mode, each assertion of L3 causes the input data to be loaded. In the single mode, only the first L3 following power-up, or following a data sampling by the Front End, is effective. The Digital I/O Board generates a BUSY signal during the time that the data is being sampled. L3 is not effective during this time. BUSY is asserted for a period of approximately 15 microseconds.

Status Input

When configured for status input, the Digital/Status Input Connector allows the Digital I/O Board to accept a maximum of 20 separate one-bit inputs from an external source for each Digital I/O Board installed in either the Front End or the 2281A Extender Chassis. Each bit is associated with a channel programmed as status input.

The Status Input configuration is achieved on the Digital/Status Input Connector by installing a jumper at input 21 and leaving input 22 open.

CAUTION

Do NOT leave both inputs 21 and 22 open. This code makes the Digital I/O act as a Status Output.

REMOVAL AND INSTALLATION

Connections from external control points or terminals to the Front End are made via external wiring to the Digital/Status Input Connector. Preparation of the Digital/Status Input Connector involves opening its connector housing, assembling and connecting the appropriate wiring on the terminals, closing the connector housing, and connecting it back to the Digital I/O board. The following steps detail this procedure:

WARNING

ENSURE THAT ALL LINE POWER TO THE FRONT END OR EXTENDER CHASSIS IS DISCONNECTED. LETHAL VOLTAGES MAY BE PRESENT WITHIN THE FRONT END AND ON SOME OPTION CARDS. DO NOT REMOVE ANY INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

The connector is designed so that installation can be accomplished without removing the associated Digital I/O Assembly.

Connector Removal

If the connector is already installed, but needs new or changed wiring connections, perform the following initial procedure:

1. With line power disconnected and the POWER switch set to OFF, locate the connector housing in the rear panel of the Front End.

2. Remove the two retaining screws that hold the housing assembly to the chassis.

3. Firmly grasp the connector housing at its midpoint and pull until the enclosed connector block is disconnected from the Digital I/O Board.

4. Open the housing by gently pressing each locking tab.

External Wire Connections

WARNING

BE SURE THAT THE WIRES BEING CONNECTED TO THE DIGITAL/STATUS INPUT CONNECTOR ARE NOT ENERGIZED. IF POSSIBLE, DISCONNECT THESE WIRES AT THE OTHER END. IN ANY EVENT, ENSURE THAT THE ASSOCIATED EXTERNAL CIRCUIT IS DEENERGIZED. HAZARDOUS VOLTAGE COULD OTHERWISE BE ENCOUNTERED.

Use the following procedure when connecting wires from the external circuit. Notice that the two terminals for each channel are marked SIGNAL and RETURN. All returns are connected together on the card and are tied to logic common on the Digital I/O Board.

WARNING

SINCE INDIVIDUAL CHANNELS ARE NOT ISOLATED FROM EACH OTHER, ALL RETURN TERMINALS ARE CONNECTED TOGETHER ON THE DIGITAL/STATUS INPUT CONNECTOR. ALL RETURN WIRES MUST BE AT THE SAME VOLTAGE.

1. Starting at channel 0, attach the external wiring for the desired application. To make each attachment, do the following:

   o Loosen the channel terminal screws.
   o Attach the external wires to the screws.
   o Tighten the screws until the wires are firmly in place.

2. Close the connector housing over the input connector, ensuring that the external wires exit the rear of the enclosure without being pinched.

Connector Installation

With all external connections in place, attach the connector assembly as follows:

1. Position the enclosed (and wired) Digital/Status Input Connector at the guides of the Front End rear panel slot containing the Digital I/O Assembly.

2. Then, grasping the Digital/Status Input Connector firmly, mate it with the Digital I/O Assembly until it is firmly in place.

3. Use the two retaining screws to secure the connector housing to the chassis.

The 2281A is used to expand the input and output capacity of the Front End. The Front End supports a system capacity of 1000 input and output channels. Hardware for these channels can be installed in either the Front End or the 2281A Extender Chassis. When connected to a Front End via its serial link cable, the modules within the 2281A are viewed by the Front End as residing in the Front End.

2281A Extender Chassis

The 2281A is shown in Figure 2281-1.

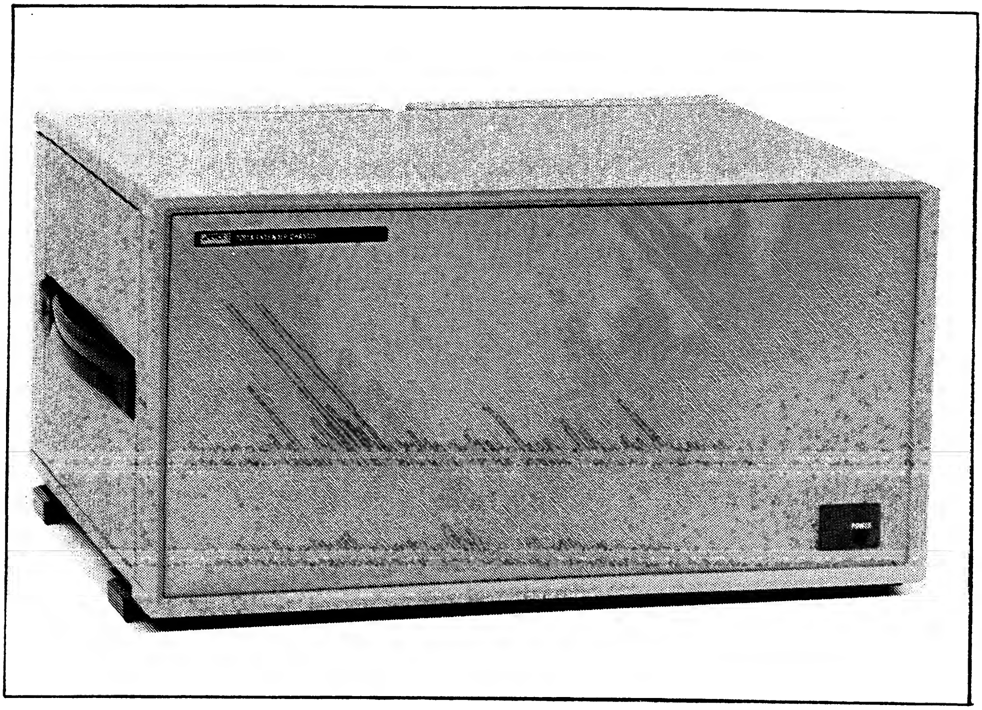


Figure 2281-1. 2281A Extender Chassis

Using the 2281A extender in the Front End can be advantageous.

- o Cost effectiveness is realized when long runs of thermocouple wire are no longer necessary. For example, a maximum of 120 thermocouples (using the -165 Fast A/D Converter) can be connected to a 2281A extender, and each extender can be located up to 1 kilometer from the parent Front End.
- o Measurement accuracy at remote-sensing locations is also assured by the use of digital communication between the 2281A and the Front End.
- o Use of the 2281A broadens the operating temperature range of serial link options by removing those devices from more temperature-sensitive components residing within the Front End.

The 2281A receives operating power by one of two paths. First, it can receive power through the serial link cable. Second, it can receive power through a 2281A-431 Power Supply installed in a 2281A chassis. The 2281A-431 is described later in this section.

The 2281A can be located with considerable flexibility relative to the Front End.

- o Star configurations can be supported with the Y2047 multiconnect accessory.
- o Multipoint configurations can be directly supported by the 2281A Extender Chassis.
- o For either configuration, the maximum allowable length of cable from the 2281A extender to the Front End mainframe is one kilometer.

The Front End and Extender Chassis form a distributed system concept that is illustrated in Figure 2281-2.

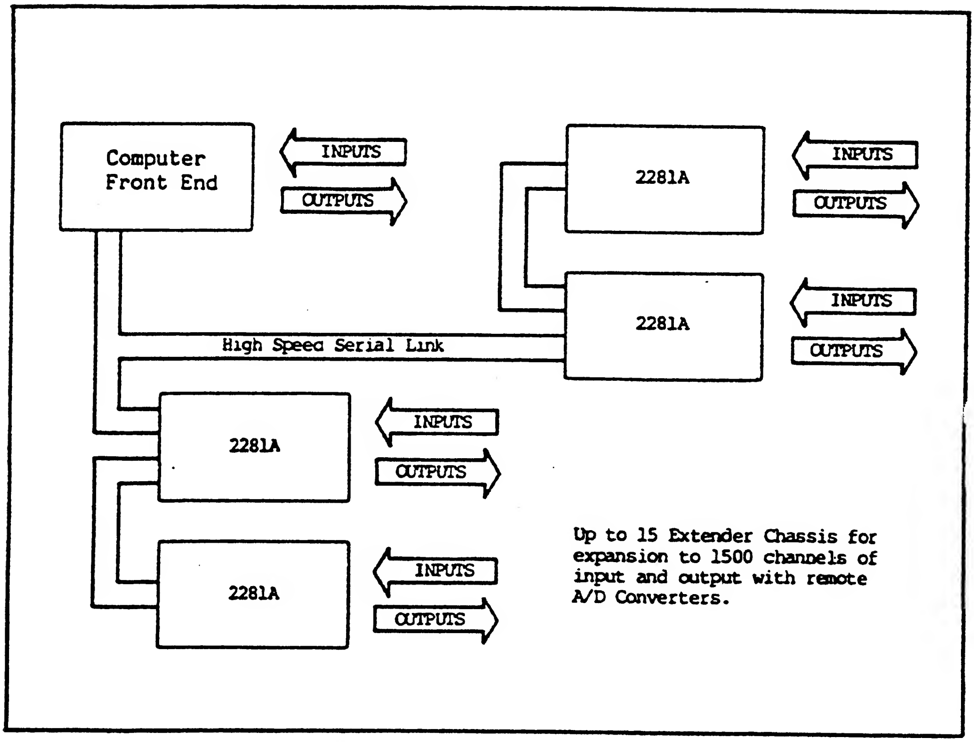


Figure 2281-2. Distributed System Concept

The 2281A may be stacked on top of other full-width Fluke instruments, bench mounted, or rack mounted using the Y2045 Rack Mount Kit or the Y2044 Rack Slide Kit. In some remote Extender Chassis applications it will be necessary to configure the 2281A with the -431 Power Supply.

Additional information is available in the 2281A Instruction Manual, as amended by the information presented here in Section 3B. Specifically, power requirements for the Front End differ from those mentioned in the 2281A Instruction Manual. The Front End provides +12V, not +24V. Refer to "Determine Extender Chassis and Additional Power Requirements" earlier in this section.

DESCRIPTION

The -402 Extender Cable with the -403 provides the serial link interface for transmitting and receiving data between the Front End and the 2281A. Power for the 2281A Extender Chassis is also provided over this cable from the Front End or a 2281A-431. The Extender Cable consists of six shielded twisted pairs and is sold by the meter. The -403 connector completes this assembly.

Three of the twisted pairs carry the +12V dc (and returns) from the Front End to the 2281A. RS-442 data is transmitted over TX+ and TX- from the Front End on one twisted pair while RX+ and RX-, the received data from the serial link devices within the 2281A, are carried over another pair of twisted wire. The last twisted pair connects the +5V dc return (+5RTN) from the Front End for signal ground continuity with the 2281A.

Cable pin identification for the -403 connectors can be found with the -403 information. A cable diagram (with connectors installed) is included in this information.

DESCRIPTION

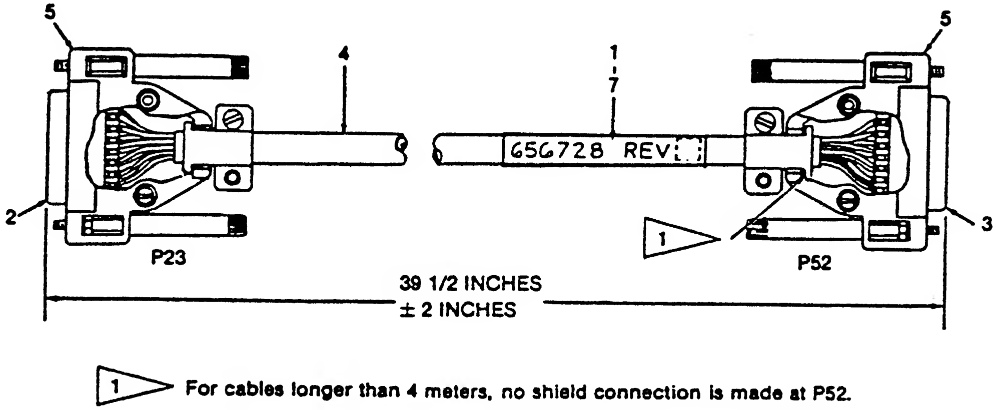
The 2281A-403 Extender Cable Connector is a set of male/female 15-pin, D-type connectors. A housing provides strain relief for cable connections and stand-off bolts for securing the cable connector to the mainframe connector. The cost includes factory installation onto the 2281A-402 Extender Cable and continuity testing before shipment.

Table 403-1 shows the pin identification of the two connectors. Figure 403-1 shows the -403 connectors assembled to the Extender Cable. Individual connector part numbers (for replacement only) are also listed in Figure 403-1.

Table 403-1. Connector Pin Identification

SIGNAL MNEMONIC	P23 PIN NUMBER	P52 PIN NUMBER
+24 VDC	1	1
+24 VDC	2	2
+24 VDC	3	3
+5 RTN	5	5
+5 RTN	6	6
RX -	7	7
RX +	8	8
+24 RTN	9	9
+24 RTN	10	10
+24 RTN	11	11
TX -	13	13
TX +	14	14
SHIELD	15	15*

*For cables longer than 4 meters, no shield connection is made at P52.



QTY	ITEM	PART NO.	DRAWING NO.	DESCRIPTION
1	1	610600	2281A-2010	LABEL
1	2	436881		CONN, 15 PIN
1	3	436899		CONN, 15 SOCKET
3.291ft	4	682773		CABLE
2	5	682765		CONNECTOR HOUSING
.55ft	6	113845		SLEEVING
.27ft	7	295782		THERMOFIT, CLEAR

Figure 403-1. Internal View

INTRODUCTION

This subsection presents descriptive and installation information for the 2281A-431 Power Supply.

The 2281A-431 is more fully described in the 2281A Instruction Manual. The following additional items can be found in the 2281A manual: Specifications, Theory of Operation, Performance Test, Calibration Procedures, Parts List, and Schematic Diagram.

DESCRIPTION

The -431 Power Supply is a rear panel-mounted dc power supply for the 2281A Extender Chassis. The power supply provides a regulated 20V dc source for the serial link devices when the Extender Chassis placement (distance) and configuration (number of serial link devices) exceeds the power capabilities of the Front End.

Requirements for the -431 power supply are discussed in the 2281A Instruction Manual and earlier in Section 3 of this manual (see "4. Determine Additional Power Requirements").

The -431 may accept input power sources of ac line voltages, +12V and +24V dc voltages. The power supply has an automatic crossover from ac line to 12V dc and 24V dc to the 12V dc input. In addition, while the -431 is operating from ac line or 24V dc, a trickle charge is provided to the 12V dc input for maintaining the charge of a backup battery.

The power supply pwb (printed wiring board) is installed in place of the extender interface card and the power supply rear panel assembly is installed in place of the extender interface rear panel. The power supply rear panel provides a serial link feed-through for interconnecting multiple Extender Chassis. An illustration of the rear panel assembly is shown in Figure 431-1, and a detailed description is provided by Table 431-1.

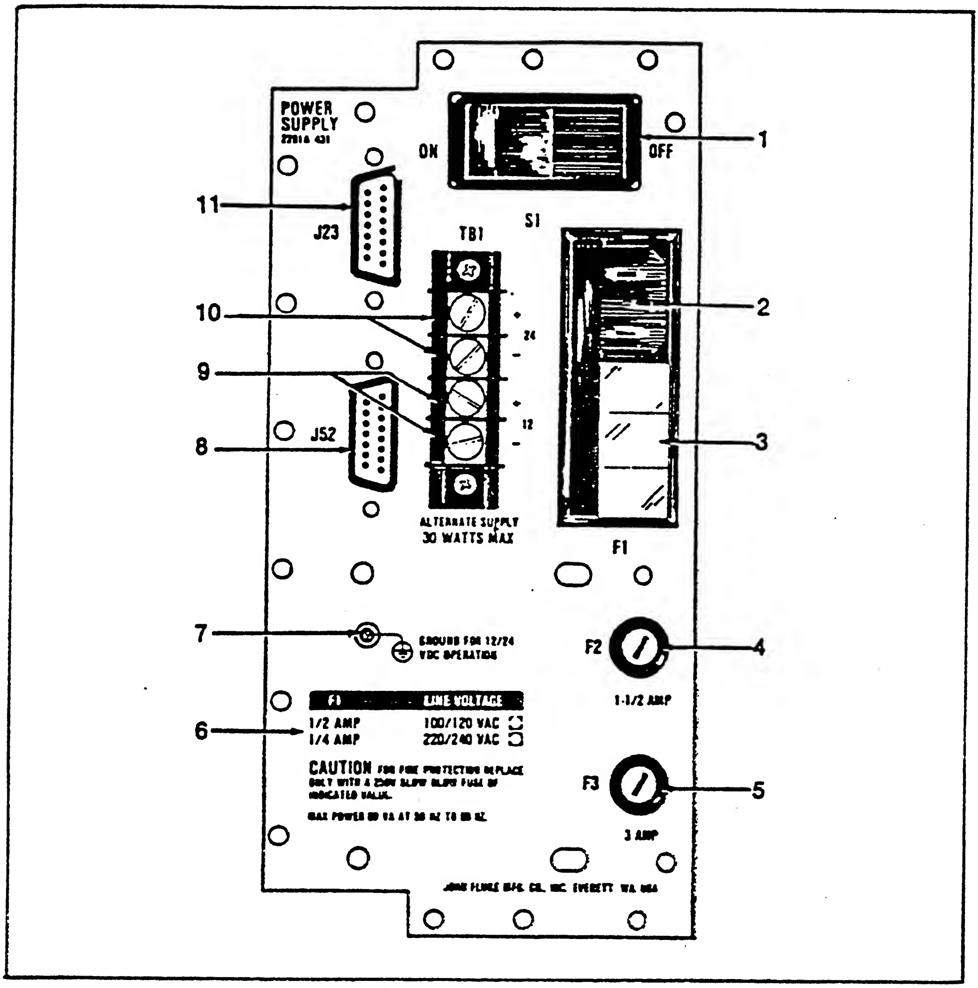


Figure 431-1. Rear Panel Assembly

Table 431-1. Rear Panel Features

ITEM	FEATURE NAME	DESCRIPTION
1	S1	ON/OFF power switch, for ac line and dc voltages.
2	ac input	Standard male ac input socket.
3	F1	Fuse holder for ac line fuse. Sliding plastic door prevents access while ac line power is connected.
4	F2	Fuse holder for 24V dc input.
5	F3	Fuse holder for 12V dc input.
6	Fuse/Voltage	Silkscreened annotation of ac Fuse ratings and line voltage selection.
7	Ground Lug	Threaded ground lug termination for dc inputs.
8	J52	15 pin, male connector for serial link extender cable from the 2280A.
9	TB1 (12)	Terminal block connection points for the 12V dc input or backup battery.
10	TB1 (24)	Terminal block connection points for the 24V dc input.
11	J23	15 pin, female connector for serial link extender cable feedthrough to another 2281A.

INSTALLATION

Hardware Installation

Use the following procedure to install the -431 Power Supply into the Extender Chassis. After completing the hardware, electrical, and cabling installation sections, complete the initial verification procedure (given in the later part of this section).

1. Remove all the Phillips screws from the extender interface rear panel assembly.

2. Pull out the rear panel and pwb assembly. They should be affixed by the pwb connector cable retaining nuts.

3. Remove the connector cable retaining nuts from the power supply pwb.

4. Plug P54 (from power supply rear panel assembly) into J54 (on power supply pwb assembly).

NOTE

The connector is keyed; DO NOT FORCE. To release, squeeze the side tabs on the connector.

5. Slide the pwb into the left-most slot of the Extender Chassis until P12 is seated in the motherboard connector J12.

6. Secure the power supply rear panel assembly over the pwb using 12 Phillips screws.

7. Replace the cable retaining nuts of the power supply pwb connector.

8. Hardware installation is now complete.

Electrical Installation

The 2281A-431 is shipped with the proper operating voltage already selected as specified by the customer. The following paragraphs explain how to reconfigure the 2281A-431 for other voltage settings and how to connect the 2281A-431 to the system. After completing the hardware, electrical, and cable installation sections, complete the installation verification procedure (given later in this section).

Input Voltage Selection

To power the 2281A-431 with 24V or 12V dc, the appropriate supply is connected to a terminal block (TB1) on the power supply rear panel. It is recommended that power source cables be terminated with No. 6 spade lugs for safety and convenience. Table 431-2 lists the proper fuse ratings for all voltages. The following procedure and Figure 431-2 show how to reconfigure the 2281A-431 to a different ac line voltage.

1. Open the cover door on the ac input module (under S1) and rotate the "fuse-pull" lever to the left to remove the fuse.

2. Using a pair of pliers, grasp the small pwb, located underneath the fuse holders, between the metal tabs and remove.

3. Reinstall the pwb so that the required operating voltage is shown in the opening as in Figure 431-2A. Push the pwb in firmly.

4. Slide the fuse-pull lever to the right, and insert the proper fuse (F1) for the selected operating voltage. See Table 431-2 for fuse ratings.

Table 431-2. Fuse Ratings

REF DES	SUPPLY	RATING
F1	100/120V ac	1/2 A/250V Slow Blo
F1	220/240V ac	1/4 A/250V Slow Blo
F2	+24V dc	1.5 A/250V Fast Blo
F3	+12V dc	3.0 A/250V Fast Blo

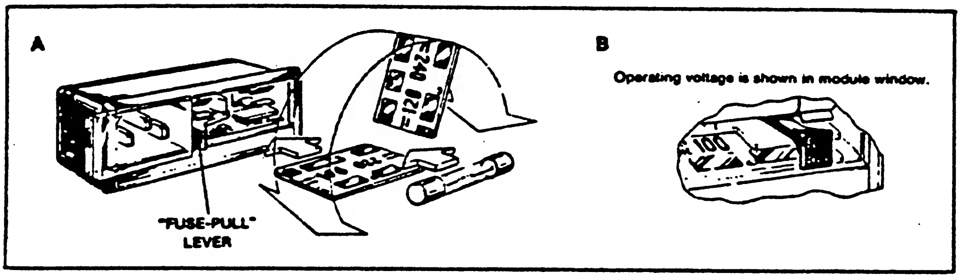


Figure 431-2. AC Voltage Selection

2281A-431 Cable Connections

Figure 431-3 illustrates the 2281A-431 cabling for ac and dc operation. After completing the hardware, electrical, and cable installation sections, complete the installation verification.

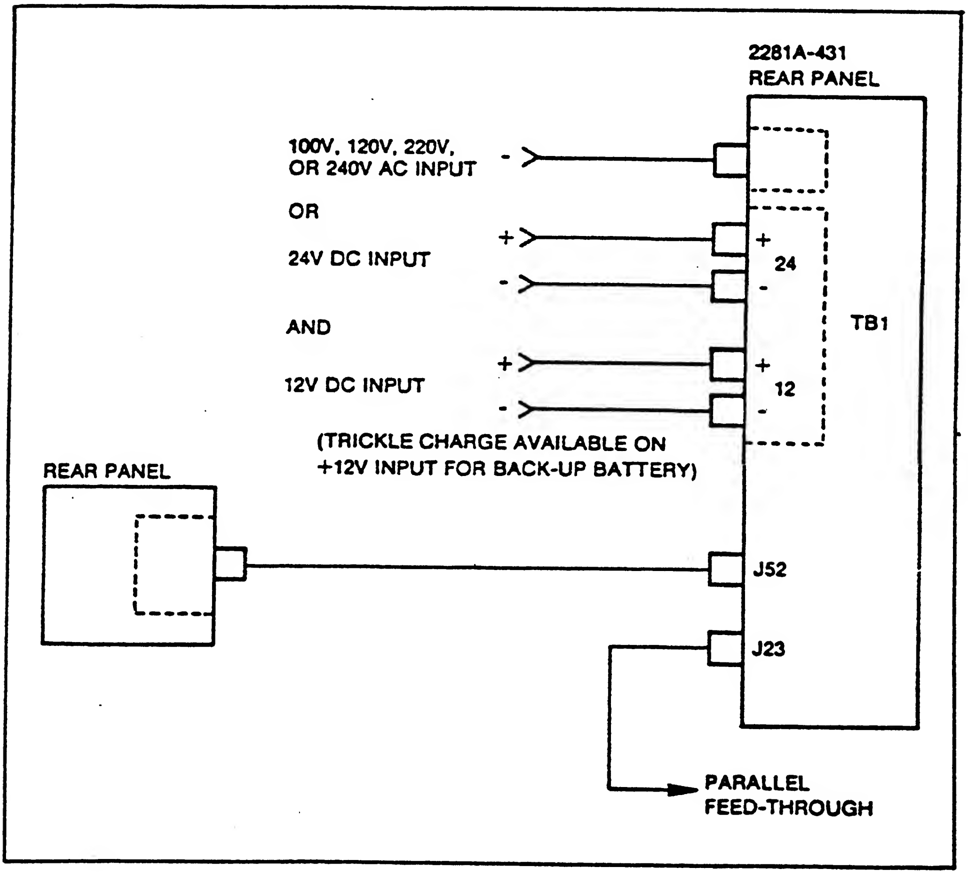


Figure 431-3. Cabling Diagram

INSTALLATION VERIFICATION

This procedure is used to verify the proper operation of the 2281A-431 after it is installed in the 2281A. No special tools or test equipment are required.

1. Connect ac or +24V dc power to the -431. When using the 2287A, connect the serial link cable to J52 on the -431.

2. Set S1 on the 2281A-431 rear panel to ON.

3. Switch on power to the Front End. Verify that the 2281A-431 front panel LED is illuminated.

4. Turn off power to the Front End. Verify that the front panel LED extinguishes.

5. If a 12V back-up battery is connected to TB1, complete the following steps.

   a. Set S1 to OFF.

   b. Disconnect the ac line and/or +24V dc source.

   c. Set S1 to ON.

   d. Switch on power to the Front End. Verify that the 2281A front panel LED is illuminated.

   e. Switch off power to the Front End. Verify that the 2281A front panel LED goes off.

6. This concludes the installation verification procedure for the 2281A-431. Switch off all power sources to the 2281A-431 before dismantling the test setup.

Y2044
Rack Slide Kit

DESCRIPTION

The Y2044 Rack Slide Kit facilitates the servicing of the Front End (or 2281A) while it is installed in a standard 19-inch electronic equipment rack. The unit is secured in the equipment rack, yet may be pulled out along the slide for reconfiguring and servicing serial link devices. Parts and hardware for this kit are listed in Table 1. The only tools required for installation are medium-sized, Phillips and flat-head screwdrivers.

INSTALLATION

The rack slide kit is shipped in two separate containers. All necessary hardware for installing the kit is contained in the wrapped package. All required parts and hardware for the rack slide kit are listed in Table 1. After verifying that all kit parts are present, proceed to the installation procedure.

Table 1. Parts and Hardware

ITEM	NAME	DESCRIPTION
1	Chassis Track	Two gray metal slide tracks (packaged in a cardboard box).
2	Rear Support Bracket	Two machined metal angle brackets (packaged in a cardboard box).
3	Bar Nuts	Six metal strips with four threaded holes.
4	Rack Ears	Two white machined angle pieces.
5	Slide Spacer 8.4 Inches	Two 8.4 inch pieces of metal bar stock with five punched holes and two 5.85 inch pieces of metal bar stock with two punched holes (for use with 2280B only).
6	Rack Ear Hardware	A small envelope containing eight machine screws with plastic washers, and clipnuts.
7	Miscellaneous Hardware	The following screws are used to install the Rack Slide Kit: twelve 8-32 x 7/8" Phillips twelve 10-32 x 3/8" pan-head Phillips

NOTE

Some of the parts included with the Y2044 may not be used. Once, the installation is complete, discard any unused parts.

The installation procedure for the Y2044 is as follows.

1. Remove the four molded plastic feet from the bottom cover of the instrument.

2. On both front side corners of the instrument remove the decals bearing the Fluke name.

3. Refer to Figure 2044-1 and complete these steps:

   a. Remove the three screws (indicated by asterisks) from both sides of the instrument.

   b. Placing the cutout side of the rack ears against the front corner of the instrument, align the recessed holes with the holes vacated in step a.

   c. Secure the rack ears to the instrument using six of the 8-32 x 7/8-inch screws.

   d. Remove the instrument side handles by unfastening the two Phillips screws.

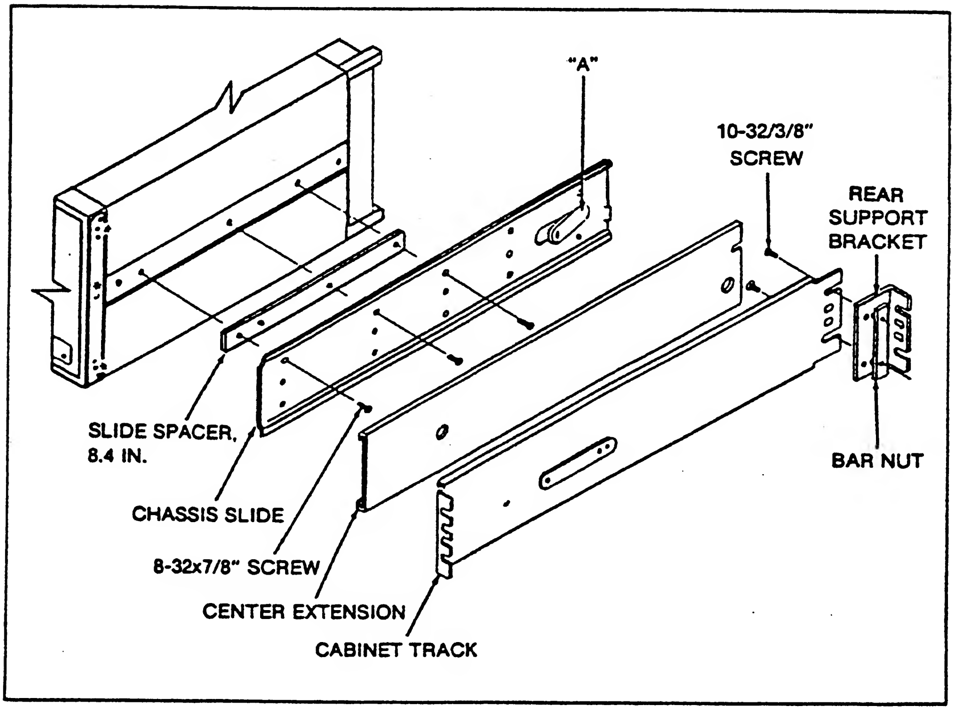


Figure 2044-1. Installation Details

e. Disassemble the chassis slide of the chassis track by fully retracting the extensions and releasing the spring-loaded retaining button marked with an "A".

f. With the slide spacer in place, secure the chassis slide to the instrument using three 8-32 x 7/8-inch screws (for both sides).

NOTE

Use the upper row of mounting holes on the chassis slide.

g. Attach the rear support bracket flush with the end of the cabinet slide using a bar nut and two of the 10-32 x 3/8-inch screws (on each chassis track).

h. Insert the center extension of the chassis track into the cabinet slide, aligning the retaining button with the center extension hole.

i. Install the assembly from step (h) into the equipment rack using bar nuts and 10-32 x 3/8-inch screws in the top and bottom slots of the cabinet slide ends.

j. Extend the center extension towards the front of the equipment rack until it locks.

k. Insert the chassis slide into the center extension, depressing the retaining button as it slides in.

NOTE

At this point it may be necessary to readjust the chassis track to align the rack ear mounting holes with those of the equipment rack.

l. Attach the clip nuts to the equipment rack, matching the hole pattern in the rack ears.

m. Use the machine screws (with plastic washers) to secure the instrument and prevent it from sliding out.

DESCRIPTION

The Y2045 Rack Mount Kit facilitates the placement of a Front End or 2281A Extender Chassis into a standard 19-inch electronic equipment rack. Parts and hardware for this kit are listed in Table 1. The only tool required for installation is a medium-sized, Phillips screwdriver.

Table 1. Parts and Hardware

INSTALLATION

Remove the contents of the Y2045 from its shipping container and compare the contents to Table 1. After verifying that all kit parts are present, proceed with the following installation procedure.

1. Remove the four molded plastic feet from the bottom cover of the instrument.

2. On both front side corners of the instrument, remove the decals bearing the Fluke name.

3. Refer to Figure 2045-1 while performing the following steps.

   a. Remove the three screws indicated by the asterisk from both sides of the instrument and discard the screws.

   b. Placing the cutout side of the rack ears against the front corner of the instrument, align the recessed holes with the holes vacated in step a.

   c. Secure the rack ears to the instrument using the six 8-32 x 7/8-inch screws.

4. Note the orientation of the instrument's shelf bracket in Figure 2045-1. Install the shelf bracket into the equipment cabinet using two 10-32 x 3/8-inch screws on each of the four tabs.

5. Insert the instrument three-fourths of the way into the equipment cabinet along the shelf bracket.

6. Attach the clip nuts to the front flange of the equipment cabinet aligning the clip nuts with the slotted holes of the rack ears.

7. Slide the instrument into the equipment cabinet and secure it using the machine screws.

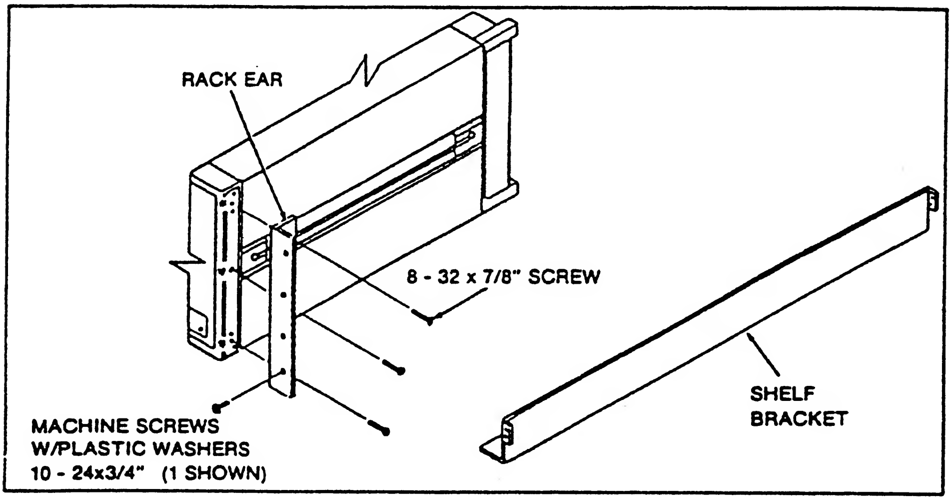


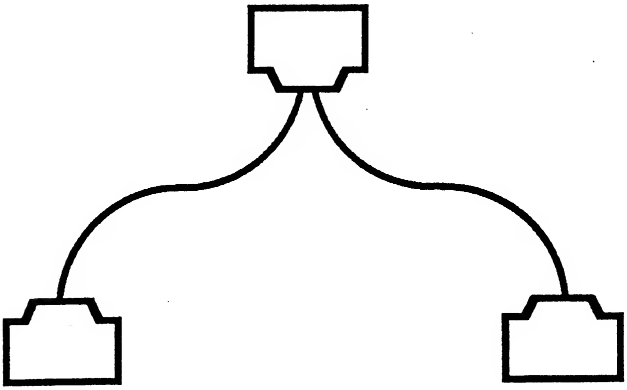
Figure 2045-1. Installation Details

The Y2047 Serial Link Multiconnect is used in 2281A placements to support star configurations. Examples of star configurations are shown in Section 2 of the 2281A Instruction Manual.

The Y2047 contains two D-type, 15-pin sockets on one face of its 1 3/4-inch x 1-inch x 1 3/4-inch metal housing and a single D-type, 15-pin plug on the opposite face.

The Y2047 male plug can be connected to J23 on the rear panel of the Front End or the 2281A Extender Chassis. If a star connection is desired from a 2281A with a -431 installed, the Y2047 must be connected to J23 (2281A) using either a -402 Extender Cable (with -403 Extender Cable connectors) or the cable supplied with the 2281A. Use the two Phillips screws on the reverse side, between the two parallel sockets, to secure the Y2047 to the cable retaining nuts of J23.

Accessory Y1060 25-Conductor Multi-Connector is a three-way connector assembly necessary in a multipoint RS-422 network. It is comprised of three subminiature 25-pin D-type connectors with all signal lines connected in parallel. One Y2055 25-Conductor Multi-Connector is required for each Front End mainframe except the last one in an RS-422 multipoint system.



RS-232-C NULL-MODEM CABLES

An RS-232-C Null-Modem Cable is used when the Front End and the host computer are direct-connected without modems. The Null-Modem cable reverses the pins carrying Transmitted Data (TD) and Received Data (RD). It takes the place of two modems when a direct-connect network is desired.

The following Fluke RS-232-C Null-Modem Cables are complete with connectors:

- Y1702 -- 2m RS-232-C Null-Modem Cable
- Y1703 -- 4m RS-232-C Null-Modem Cable
- Y1705 -- 30 cm RS-232-C Null-Modem Cable

The Y1705 is intended to be used in conjunction with a standard RS-232-C cable.

Wiring for these cables is shown in Figure 17XX-1. Pin signal names are identified in Table 17XX-1.

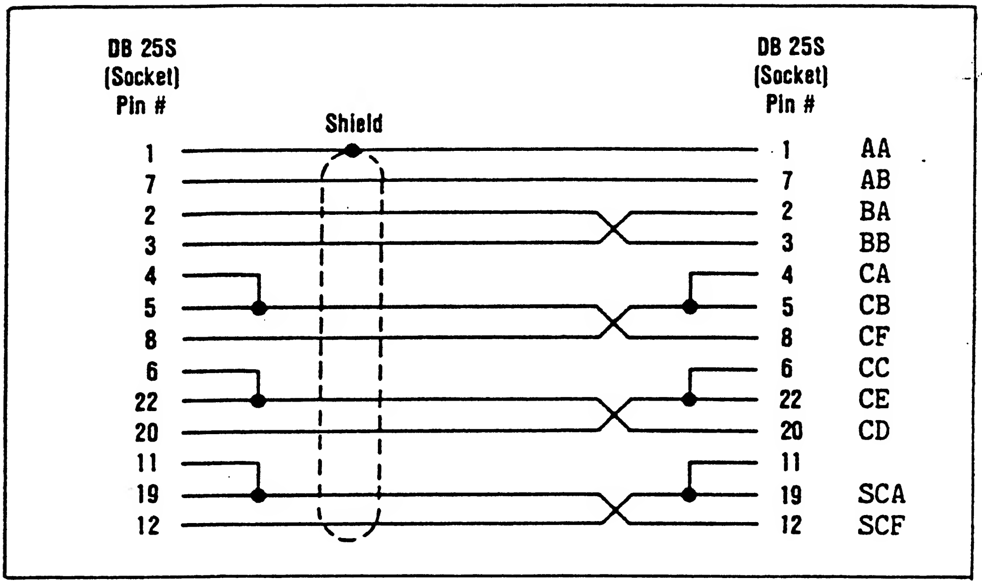


Figure 17XX-1. Y1702, Y1703, Y1705 Wiring

RS-232-C INTERFACE CABLES

These cables may be used to connect the Front End to Data Communication Equipment (DCE). An example of DCE is a modem. RS-232-C cables complete with connectors are available from Fluke as the following accessories:

- o Accessory Y1707 -- 2m RS-232-C Cable
- o Accessory Y1708 -- 10m RS-232-C Cable

Refer to Figure 17XX-2 for cable wiring connections. Pin signal names are identified in Table 17XX-1.

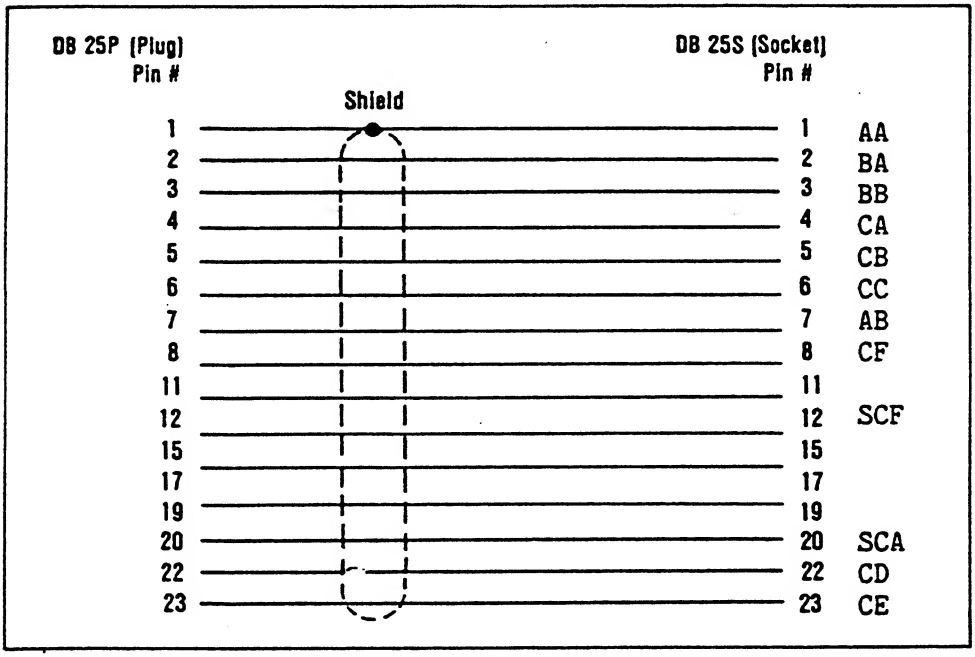


Figure 17XX-2. Y1707, Y1708 Wiring

PRINTER CABLE

The Y1709 is a 1m cable allowing for serial printer connections. Wiring is illustrated in Figure 17XX-3. Pin signal names are identified in Table 17XX-1.

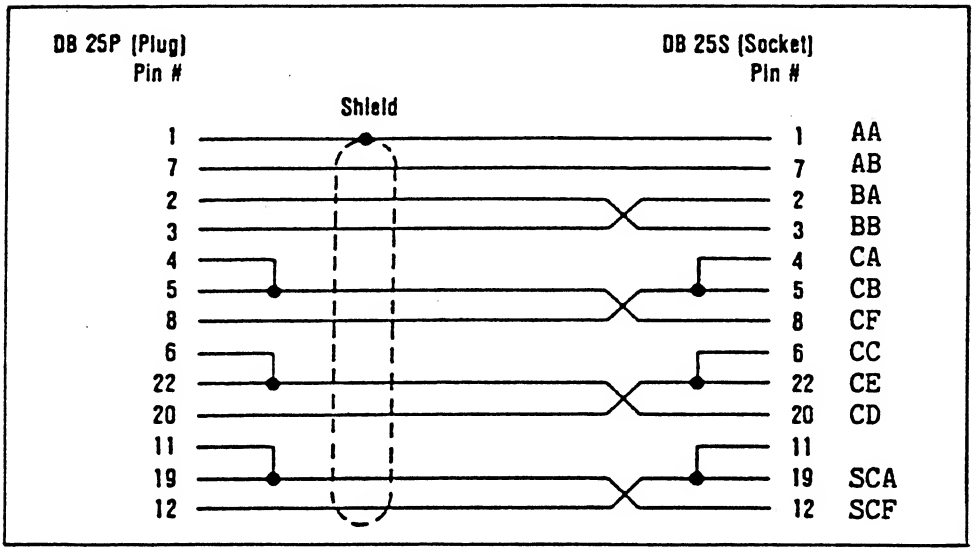


Figure 17XX-3. Y1709 Wiring

Table 17XX-1. RS-232-C Pin Identification

AA	1	Protective Ground
AB	7	Signal Ground
BA	2	Transmitted Data
BB	3	Received Data
CA	4	Request to Send
CB	5	Clear to Send
CF	8	Received Line Signal Detect
CC	6	Data Set Ready
CE	22	Ring Indicator
CD	20	Data Terminal Ready
	11	Unassigned
SCA	19	Secondary Request to Send
SCF	12	Secondary Received Line Signal Detect

MAINFRAME INTERFACE TESTING

When interface configuration and installation is complete, test the system to verify correct operation. The following installation verification test should be performed regardless of the type of host computer you are using.

Note that this test procedure only checks the communications interface. It does not test any installed option assemblies. If option assemblies are installed during a failed test, remove the options and repeat the test.

Follow these steps to verify correct installation and operation of the interface:

1. Connect the host computer to the Front End using the appropriate equipment and cables for the type of electrical interface (RS-232-C or RS-422). Check to make sure each connection is tight.

2. Connect the host computer and the Front End to line power.

3. Set the Front End POWER switch to ON.

4. Switch the host computer on. If this is a multi-point connection, establish the line connection as discussed in Section 3A, under "Mainframe Multidrop Configuration." Briefly, this procedure amounts to sending first the address of the desired Front End, then the ENQ character. A two-point direct-connect system does not require this step.

NOTE

Send Helios Plus a Carriage Return by pressing the ENTER key.

o "HCLI"

This response means that Helios Plus is in terminal mode. Proceed to step 5.

o "!"

This response means that Helios Plus is in computer mode. But computer mode does not echo characters that you enter, thus providing an incomplete visual interface during this verification test. Solve this problem by commanding Helios Plus to enter the terminal mode. Type the following:

MODE = TERM <ENTER>
EOL = 10,13 <ENTER>

Now proceed to step 5.

o (nothing)

If Helios Plus has not been returning anything when you press ENTER, there is a more basic problem with the cabling, baud rate, parity, or some other setup parameter. Check these items before proceeding.

5. Send the following command to the Front End from the host computer:

   SEND VERSION$

6. Verify that the response from the Front End to the host computer indicates something like the following:

Helios Plus Version 1.0 Software by John Fluke Mfg. Inc.

If the system does not function properly, check all connections, then try the installation verification test again. If the system fails to function properly the second time, verify the interface of the host computer with another system or device to eliminate the computer as the source of the problem. If the host computer functions properly, contact your nearest Fluke Service Representative.

MAINFRAME ALARM OUTPUT TESTING

To test the alarm outputs, first perform the mainframe tests presented earlier in Section 3C. If a printer is being used, make the related connections called for in Section 3A. Then use the following steps to verify correct installation and operation of the alarm outputs.

1. On the alarm annunciator connector, connect a wire between pin 6 and pin 8.

2. From the host computer, send the following command to the Front End:

   HOSTTO = 1

3. After about one second, check for a printer message indicating that the host computer is off line. Also, the audible alarm contacts (pins 1 and 3) should close, and the visual alarm contacts (pins 2 and 4) should begin opening and closing.

4. Remove the wire from pin 8. Now, momentarily connect it to pin 7, then reconnect it to pin 8. Check that the visual alarm contacts close and remain closed and that the audible alarm contacts open.

5. Send the following command from the host computer to the Front End:

   HOSTTO = 0

6. Check that the visual alarm contacts open.

If the system does not function properly, check all connections and switch settings. Then try this alarm output verification procedure again. If the system still fails to function properly, verify that the host computer interfaces successfully with another system or device. If this interface test is successful, the host computer is not the source of the problem. At this point, contact your nearest Fluke Service Representative.

OPTION ASSEMBLY TESTING

Once the mainframe installation test has been passed, and after option assemblies have been installed, the LIST CHAN command can be used to verify the hardware configuration. Use this format:

LIST CHAN (channel[s])

This command returns a listing of the definitions of designated channels. Each listing describes both hardware configurations and software channel definitions. The form in which a listing is returned depends on whether the front end is operating in the Terminal (TERM) or Computer (COMP) mode.

In the Computer Mode, the LIST CHAN(channel[s]) command returns six numeric fields on a single line. Fields are separated by commas. Each field represents a hardware configuration or element of a channel's definition.

In the Terminal Mode, channel definition data are returned as alphabetic, rather than numeric, strings, making them more readily understandable.

Refer to Section 5, LIST CHAN for full descriptions of listing responses. Also, refer to the appropriate type of measurement or output described in Section 6, where examples entitled "Putting it all Together" can be used to verify hardware installation.

Section 4
Using the Commands

CONTENTS

INTRODUCTION

The Front End can be programmed and operated using a terminal, a computer, or a computer running a terminal emulation program. Operation amounts to the computer or terminal sending commands to the Front End and reading back or displaying the Front End's responses to the command. This section presents an overview of communications, describing commands understood by the Front End, methods of sending these commands from the terminal or computer, and responses read by the computer or displayed on the terminal.

The Front End can be used in one of two communication modes. The first, Terminal Mode, provides descriptive prompts and messages. The second, Computer Mode, uses abbreviated prompts and messages (usually abbreviated to numeric codes) to simplify operation of the Front End from a computer program.

Either mode can be used to control the Front End. The following considerations should be made when deciding which mode to use.

- Speed. Computer Mode allows for faster communication. It best complements the speed of the controlling computer when the front end is under direct program control.

- Clarity of Feedback. Terminal Mode provides more meaningful feedback to the operator. Command characters appear on the terminal screen as they are typed, and returned measurements and error information are provided in descriptive phrases.

- Editing of Inputs. Terminal Mode allows some editing of commands as they are being entered. Typing mistakes can be corrected. Computer Mode allows no editing of commands.

COMMAND FORMAT

The Front End uses a straightforward command structure. Examples of commands are:

```
SEND VERSION$ <CR>
DEF CHAN(0..19)=DVIN <CR>
FORMAT = HEX <CR>
```

where <CR> represents a carriage return character. Depending on the type of computer or terminal, this character may be entered with the RETURN, ENTER, return arrow, or other key.

As shown above, a command to the Front End has three parts: it begins with a word that identifies the type of command, is followed by a list of parameters that further describe the operation to be performed, and is completed with a carriage return character. A <CR><LF> (where <LF> represents a line feed) sequence can also be used to terminate commands.

Commands to the Front End use many different words. The examples above used the words:

SEND	VERSION$	DEF	CHAN
DVIN	FORMAT	HEX	

These words can be sent to the Front End using upper or lower case characters or a combination of both. These words are all equivalent:

SEND   send   Send

Spaces cannot occur within a word.

A command must be 80 characters or less. Commands longer than 80 characters are truncated, often resulting in a command syntax error.

STANDARD COMMAND SET SUMMARY

The Standard Command Set can be used with both the High Performance A/D and Fast A/D converters. An additional set of commands, described later in this section, is for use only with the Fast A/D Converter.

The standard commands of the Front End are organized into the following functional groups.

- Definition (DEF) commands establish the characteristics of measurement or output channels and the transfer function of linearization tables.
- Set commands are used to change the values of system variables and output channels.
- LABEL CHAN customizes printer output.
- LIST commands retrieve information about channel setup, interpolation table contents, and error history.
- RESET commands allow channels, groups of channels, or the entire Front End to be put in a known operating state.
- SEND commands fetch the reading on a channel, group of channels, or obtain the current value of a system variable or output channel.
- SHOW commands retrieve records from a buffer.
- START SCAN initiates a scan task.
- STOP SCAN stops a scan task.
- TEST commands check the operability of a channel, group of channels, or the entire Front End.

- The repeat command ("!") provides a shorthand method to repeat the execution of the previous command.

The following paragraphs provide a more detailed introduction to the commands. A complete description of each command is presented in Section 5, Command Reference.

Definition (DEF) Command

Defines measurement and output channel parameters including signal conditioning selection and engineering unit conversion. Use the format:

```
DEF CHAN(<channels>) = <definition parameters><CR>
```

As an example, define channels 0 through 19, 24 and 40 through 59 as type J (National Bureau of Standards) thermocouple inputs.

```
DEF CHAN(0..19, 24, 40..59) = TC, TYPE = JNBS <CR>
```

DEF CHAN can also be used to define a maximum of four limits, along with a hysteresis value and an alarm output channel. The full format is described in Section 5 of this manual. A new example, based on the previous example, sets a 20-degree span (120 to 100 degrees). Readings below 100 or above 120 create an alarm output on channel 100.

```
DEF CHAN(0..19, 24, 40..59) = TC, TYPE = JNBS,&
HIHI = 120, LOLO = 100, ALARM = CHAN(100) <CR>
```

Finally, DEF CHAN is used to define a special math function (channel function, or CHFN) for a set of channels. Available functions include interpolation tables, polynomial functions, and square root functions.

The definition command is also used to define interpolation tables. Use the following format:

```
DEF TABLE(<table number>) = <table x-y pairs><CR>
DEF TABLE(<table number>) = / <table x-y pairs> <CR>
```

For example, define table 0 to multiply a measurement by 2.

```
DEF TABLE(0) = 0,0 / 1,2 <CR>
```

Now, add two x-y pairs to the end of table 0.

```
DEF TABLE(0) = / 3,6 / 4,8 <CR>
```

Other DEF commands allow you to set up an alarm buffer for temporary storage of alarm data (DEF ABUF), create a scan buffer for storage of scan data (DEF SBUF), or define periodic scanning of sets of channels (DEF SCAN).

Set Command

The set command differs somewhat from other commands in that a special word is not required at the beginning of the command. The first word of the command is the name of the system variable or output channel to which a value is being assigned.

Analog output and status output channels and system variables can have their values set.

Detailed descriptions of the system variables are provided in Section 5, Command Reference. They are also listed at the end of this command description.

The following formats can be used:

```
CHAN(<output channels>) = <value> <CR>

<system variable name> = <value> <CR>
```

For example, set the output on analog output channel 101 to 4.9.

```
CHAN(101) = 4.9 <CR>
```

Or, set the output on status output channel 120 to 1.

```
CHAN(120) = 1 <CR>
```

This command sets the time string to 6 o'clock.

```
TIME$ = 06:00:00 <CR>
```

System Variables

Following is a brief description of each system variable. More detailed information is provided in Section 5.

CAL	Enables or disables auto calibration.
COUNT	Enables sending count of number of readings returned in a SEND CHAN command.
DATE$	Date in dd-Mmm-yy format (e.g., 01-Jan-86).
EOL	Sequence of characters the Front End sends at the end of each line.
FORMAT	Selects numeric format of returned measurement values (DECIMAL, HEX, BINARY, XASCII, XBINARY, XDECIMAL, or XHEX.)
HOSTTO	Contains the timeout interval for the host communications.
INTERRUPT	Determines if host is interrupted on a change of status.
LINEFR	Power line frequency (50, 60, or 400 Hz).

MEMSIZ	Memory remaining (set by system, cannot be set using a set command).
MODE	Selects terminal or computer mode.
STATUS	Holds current status of a number of system resources.
TERM	Controls transmission of exclamation mark during Send and List commands.
TIME	Time of day in milliseconds since midnight.
TIME$	Time of day in hours, minutes, second (hh:mm:ss) format.
TUNIT	System temperature units (CELSIUS, FAHRENHEIT, KELVIN, RANKINE)
VERSION$	Software version number (set by system, cannot be set using a set command).

LABEL Command

Use the LABEL CHAN command to customize the printer port output with name and measurement units strings, engineering or fixed-point format, and cursor-control escape sequences.

LIST Command

The LIST command is useful in a number of ways.

- Obtain hardware configurations and channel definitions.

  Along with the channel definitions, the Front End's hardware configuration is returned. This makes it easy to check option configuration and verify switch settings. Use the following format:

  LIST CHAN(<channels>) <CR>

  As an example, send the current hardware configuration and definitions on channels 0 through 19.

  LIST CHAN(0..19) <CR>

- Obtain interpolation table definitions

  The format is:

  LIST TABLE(<table number>) <CR>

  For example, list the current definition of interpolation table number 4.

  LIST TABLE(4) <CR>

- Retrieve error information

  LIST ERROR <CR>

  The format of the response to this command is different for Terminal and Computer Mode. Refer to the Section 5, Command Reference, for a detailed description of the LIST command response format.

- o Check the number of records in the alarm buffer

  LIST ABUF

- o Check the maximum number of records that can be stored in the scan buffer.

  LIST SBUF

- o List the scan task definition.

  LIST SCAN

RESET Command

NOTE

Some forms of the RESET command can change system configurations drastically. Refer to the RESET/RESET ALL/RESET CHAN information in Section 5 of this manual before proceeding.

Other RESET commands are specific to a buffer. The RESET ABUF command removes alarm buffer records that have already been viewed with the SHOW ABUF command. The RESET SBUF command removes scan buffer records that have already been viewed with the SHOW SBUF command.

SEND Command

- o SEND CHAN

  This command is often used to initiate measurements and return the resulting readings, complete with engineering unit conversion. Use the format:

  SEND CHAN(<channels>) <CR>

For example, make measurements on channels 0 through 19.

SEND CHAN(0..19) <CR>

The response format to the SEND CHAN command is dependent on values for the system variables COUNT and FORMAT.

Refer to the Section 5, Command Reference, for a detailed description of the SEND command response format.

- SEND System Variable

  SEND can also be used to verify the value of a system variable:

  SEND <system variable name> <CR>

  For example, send the string indicating the software version number:

  SEND VERSION$ <CR>

- SEND ABUF

  Return, and then delete, the oldest record in the alarm buffer.

- SEND SBUF

  Return, and then delete, the oldest record in the scan buffer.

SHOW Command

The SHOW command retrieves a recently occurring record from a buffer.

- o SHOW ABUF

  View the next alarm buffer record.

- o SHOW FIRST|LAST|AGAIN ABUF

  View the oldest or newest alarm buffer record, or repeat viewing the same record.

- o SHOW SBUF

  View the next scan buffer record.

- o SHOW FIRST|LAST|AGAIN SBUF

  View the oldest or newest scan buffer record, or repeat viewing the same record.

START Command

The START SCAN command initiates a scan task, specifying the output device, interval between scans, delay before the initial scan, and period of each scan.

STOP Command

The STOP SCAN command halts an existing scan task.

TEST Command

This command is used to perform a self test on the entire system or on specific measurement or output channels. Possible formats are:

```
TEST <CR>
TEST CHAN (<channels>) <CR>
```

Repeat ("!") Command

The repeat command provides a shorthand method to repeat the execution of the previous command.

! <CR>

Special Characters

In addition to the commands introduced in the preceding paragraphs, the Front End responds to several ASCII characters. These special characters are used to implement communication flow control (such that the computer or Front End won't send characters faster than the other can consume them), initialize the instrument, and select or deselect a specific Front End in a multipoint configuration.

The following paragraphs briefly describe the function of these characters.

DELETE (DECIMAL CODE 127)

The DEL or delete character is used in terminal mode to erase the previous character while a command is being entered.

ABORT (<CTRL>/C, DECIMAL CODE 3)

The <CTRL>/C character causes the following to occur:

1. A currently executing command continues execution to completion with response outputting disabled.

2. Any characters currently in the input buffer (a partial command) are discarded.

3. Any characters currently in the output buffer are discarded.

4. Any stall condition, due to receipt of a <CTRL>/S character, is lifted.

STALL AND UNSTALL (<CTRL>/S AND <CTRL>/Q)

<CTRL>/S (decimal code 19) and <CTRL>/Q (decimal code 17) characters can be used by the computer or terminal to prevent the loss of characters if, for some reason, the computer or terminal cannot handle the characters at the rate being transmitted by the Front End. When the Front End receives a <CTRL>/S character, the transmission of characters is halted until the Front End receives a <CTRL>/Q (or <CTRL>/C) character.

The Front End does not send <CTRL>/S or <CTRL>/Q characters to the computer to stall output from the computer.

ENQ

The ENQ (decimal code 5) character is used to accomplish multipoint addressing in RS-422 installation configurations.

EOT

The single character EOT (decimal code 4) disconnects the Front End from the host computer, but any pending output is retained until reconnection.

DLE + EOT

When the Front End is set for multi-drop (MULTDRP selected), the DLE (decimal code 16) and EOT sequence unaddresses the Front End, aborting any pending output.

When the Front End is set for full duplex (FDP selected), this sequence instructs the Front End to disconnect its modem and abort any pending output.

&

The ampersand (decimal code 38) echoes end-of-line sequence. You can continue typing on the next line.

FAST A/D CONVERTER COMMAND SET SUMMARY

For channels using the -165 Fast A/D Converter, the standard command set is augmented with both new commands and additional parameters for standard commands. Most of these changes apply specifically to the Burst Scan Mode. However, the added DIFF and SINGLE parameters can be used with both Continuous and Burst Scan modes.

Definition (DEF) Command

The DEF CHAN Voltage Input command format can be modified with the DIFF or SINGLE parameter when the Fast A/D Converter is operating in Continuous Scan or Burst Scan mode.

- DIFF

  Specified for a differential measurement of a pair of voltage inputs. If either channel of the pair is specified in the DEF CHAN command, and also specified as DIFF, that channel is measured differentially.

- SINGLE

  Specified for a single-ended measurement of a voltage input. The a/d converter measures the voltage difference between an input and the a/d converter reference COMMON (SHIELD) inputs. All COMMON inputs must be at the same voltage.

DEF BSCAN defines characteristics of the Burst Scan Mode for a Fast A/D Converter. Note that the channels to be scanned must be specified with a DEF CHAN prior to defining the burst scan characteristics (DEF BSCAN).

The following parameters can be defined with DEF BSCAN:

- XTRIGTYPE

  Specifies the condition(s) (LO, HI, LOHI, or HILO) under which the external trigger input may generate a trigger event.

- FILTERCNT

  Specifies the number of scans used to filter each trigger input. When consecutive scans produce the number of trigger inputs specified by FILTERCNT, a trigger event occurs.

- TRIGPOS

  Specifies the number of scans to execute after the recognition of a trigger event.

- SCANINTERVAL

  Specifies the time in milliseconds between the start of scans in Burst Scan Mode. See DEF BSCAN.

- CAL

  This system variable controls the frequency with which certain Fast A/D Converter operations are performed. These operations include self-calibration, open thermocouple checking, and reference junction reading.

LIST Command

The LIST BSCAN command retrieves the burst scan characteristics (as established with the DEF BSCAN command) for the specified Fast A/D Converter. If no scan characteristics have been defined, the default burst scan characteristics are returned.

SEND Command

The following additional SEND commands are available for use with the Fast A/D Converter operating in Burst Scan Mode:

- SEND BSCAN

  Return all specified burst scan records for the specified Fast A/D Converter.

- SEND BSCANIPS

  Identify the burst scanning status of the specified Fast A/D Converters.

- SEND SCANSIZ

  Identify the maximum number of burst scan records which may be stored in the burst scan buffer of the specified Fast A/D Converter. This number changes as the number of channels to be scanned by the a/d converter changes.

- SEND SCANUM

  Return information that can be used to determine the number of burst scan records having occurred before and after a trigger event.

- SEND SINTERVALOVR

  Retrieve the number of the Fast A/D Converter that had a scan interval overrun.

- SEND TRIGCHAN

  Identify the Fast A/D Converter channel that caused the trigger event.

- o SEND TRIGFAD

  Determine the Fast A/D Converter that encountered the trigger event.

START BSCAN Command

START BSCAN causes the specified Fast A/D Converter(s) to start scanning in the Burst Scan Mode, according to the parameters specified in the DEF CHAN and DEF BSCAN commands.

STOP BSCAN Command

STOP BSCAN causes the specified Fast A/D Converters to stop burst scanning, freeze burst data, and start continuous scanning.

Set Command

In Burst Scan Mode, a recognized trigger event can be automatically transmitted to the host when the system variable INTERRUPT is set ON.

USE OF THE -165 FAST A/D CONVERTER

Introduction

The -165 Fast A/D Converter is capable of reading 20 differential or 40 single-ended input channels (or a mixture of both) at speeds of up to 1000 readings per second. Each Fast A/D Converter uses a block of 40 channels, with the starting address of each block being a multiple of 50. Thus, a system with two Fast A/D Converters might assign the first converter to channels 0-39 and the second converter to channels 50-89. Channels 40-49 and 90-99 would be available for Analog Output(s), Counter/Totalizer(s), and other devices requiring blocks of ten channels or less.

The Fast A/D Converter is also interchangeable (within the limits of its accuracy, ranges, and channel capacity) with the -161 High Performance A/D Converter.

The Fast A/D Converter offers two data collection modes: Continuous Scan and Burst Scan. The Continuous Scan Mode is most useful in applications where quick response and filtering for power line noise are important. The data rates available in the Continuous Scan Mode are limited. But this mode is extremely easy to use.

Burst Scan Mode is especially useful for capturing transient events for analysis after the fact. While Burst Scan Mode requires more setup and planning than Continuous Scan Mode, it is capable of much higher data rates.

Continuous Scan Mode

GENERAL

Continuous Scan Mode is used for applications that require periodic measurement channel readings with filtering for power mains noise. The a/d converter scans its inputs continuously at a rate that allows filtering to reduce noise related to the power line frequency. When readings are requested by the system controller, the most recent measurements are sent immediately with no measurement delay.

READING RATE

Continuous Scan Mode allows a Fast A/D Converter to provide readings at 70 readings per second for dc volts (DVIN) while still offering considerable noise rejection at power line frequency. Any one channel may be sampled up to 7 times per second in Continuous Scan Mode. In general, use Burst Scan Mode for higher reading rates.

The highest reading rate is achieved by sampling a group of 10 channels (or multiple of 10 channels) which have channel numbers starting with 0 and ending with 9.

If the group of channels crosses a decade boundary (e.g. a group of 10 channels starting with 3 and ending with 12) the reading rate is reduced to 35/second.

A/D CONVERTER OPERATION

The a/d converter measures all programmed input measurement channels sequentially (0 through 39, in order) and repetitively. Each channel is read four times, at evenly-spaced intervals determined by line voltage frequency. (During the period of a power line cycle, 4 (at 60 Hz) or 5 (at 50 Hz) measurement channels are measured.) For each channel, these four readings are averaged and saved in a current readings buffer. The current readings buffer contains the most recent reading for each measurement channel.

The averaging process reduces sinusoidal line frequency noise (for frequencies within 0.1% of nominal) by at least 40 dB and random noise by a factor of 2. At the end of each scan, one or more open thermocouple, reference junction, or self-calibration readings are taken. This allows internal a/d housekeeping to take place without requiring occasional time gaps in the scanning sequence.

OPEN THERMOCOUPLE DETECTION

Open thermocouples are detected by imposing a current pulse across the thermocouple inputs and measuring the size of the resultant voltage pulse. A second pulse of opposite polarity is then output to balance the effect of the test pulse, minimizing measurement errors by other devices attached to the thermocouple. The total duration of each pulse pair is 200 us (100 us for each polarity). Input circuits of other instruments can thereby filter out this pulse activity. If the test pulse voltage exceeds the maximum allowed value, that channel is flagged as having a broken thermocouple and continues to be flagged until a later test shows the thermocouple is no longer broken. Open thermocouple readings are taken at a rate high enough to provide checking for every thermocouple channel at intervals of five seconds or less.

SELF CALIBRATION

Self calibration is accomplished by periodically reading the internal reference voltages (one for each of the three lowest ranges) and comparing the measured value of the reference against internally stored calibration reference values. After 64 calibration measurements of a given reference voltage have been taken, the average value, and a similarly obtained zero voltage reference, are used to calculate gain correction and offset factors to be applied to all later readings taken using that range. The calculation of these correction factors is performed in a background mode to avoid slowing the reading rate of the A/D.

Burst Scan Mode

Burst Scan Mode is used to acquire and store a series of readings. By saving the readings on the Fast A/D Converter PCA, the Fast A/D Converter is able to take readings much faster than the rest of the system could deal with them. Further, multiple Fast A/D Converters can be used to increase the number of channels without slowing down the reading rate. The Fast A/D Converter is set up to scan the input channels, saving all readings until stopped by a command from the host computer, or until scan data collection criteria have been met following a trigger event. A trigger event occurs when one of the measurement channels crosses its HITRIGGER or LOTRIGGER value, or when an external trigger input to the a/d changes state. If a trigger event occurs, the a/d completes the scan record in progress, then takes additional scan records until the Burst Scan buffering criteria have been satisfied.

Burst Scanning is done at 1000 readings/second. However, there is 1 ms of overhead at the end of each scan. This limits how closely the scans can be spaced. While no noise filtering is done in Burst Scan Mode, a SEND command from the host still causes the latest reading (or group of readings) to be returned from the buffer on the Fast A/D Converter.

For Burst Scan operation, the a/d converter alternately acquires a scan record, performs any required housekeeping, then waits for the remainder of the time between scans parameter to elapse. Housekeeping tasks include checking for HITRIGGERs and LOTRIGGERs that have been crossed, testing for open thermocouples, taking self-calibration measurements, and checking/filtering trigger inputs. Open thermocouple detection and self calibration are performed similarly to that for Continuous Scan Mode. As each measurement channel reading is acquired, it is also saved in the current readings buffer.

While the a/d converter is scanning, scan records are stored in a large section of RAM called the scan buffer. If the scan buffer is filled, each newer record replaces the existing oldest scan record.

To access the most recent reading, use the SEND CHAN command. To access other readings, burst scanning must be stopped. Determine whether burst scanning is in progress (SEND BSCANIPS). If necessary, use STOP BSCAN to halt the scanning. Then, use SEND BSCAN to access the other readings.

TRIGGERING

Triggering is a key consideration when using Burst Scan Mode. There are two trigger sources available: channel value triggers (HITRIGGER and LOTRIGGER) and the External Trigger Input. Trigger event status is available to the software through the SEND STATUS command and to the hardware through the External Trigger Output.

Channel Value Triggers

To use Channel Values for triggering, enter values for HITRIGGER and/or LOTRIGGER on the channels of interest with the DEF CHAN command. Channel value triggering is illustrated in Figure 4-1.

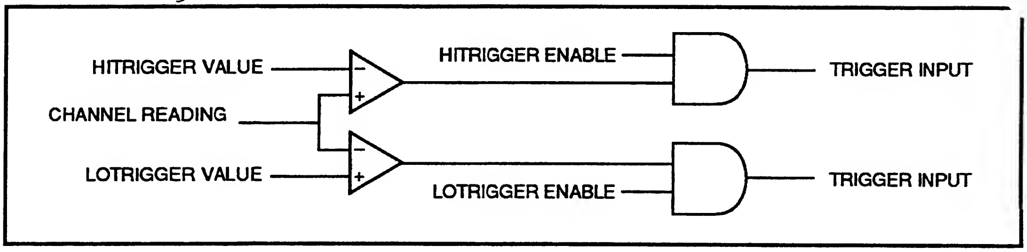


Figure 4-1. Channel Value Triggering

External Triggers

Using the External Trigger input to cause a trigger event requires putting the hardware jumper in the right position on the a/d converter and specifying the trigger conditions with a DEF BSCAN command. The external input sequence is demonstrated in Figure 4-2.

The external trigger circuitry provides both an input and an output. The output goes low when a trigger event occurs, whether or not the trigger came from the external trigger input. The output is useful for triggering other a/d converters or for providing a hardware signal when a trigger event has occurred.

You can logically combine the Hitrigger OR Lotrigger OR External Trigger input together to handle more complex situations. See Figure 4-3.

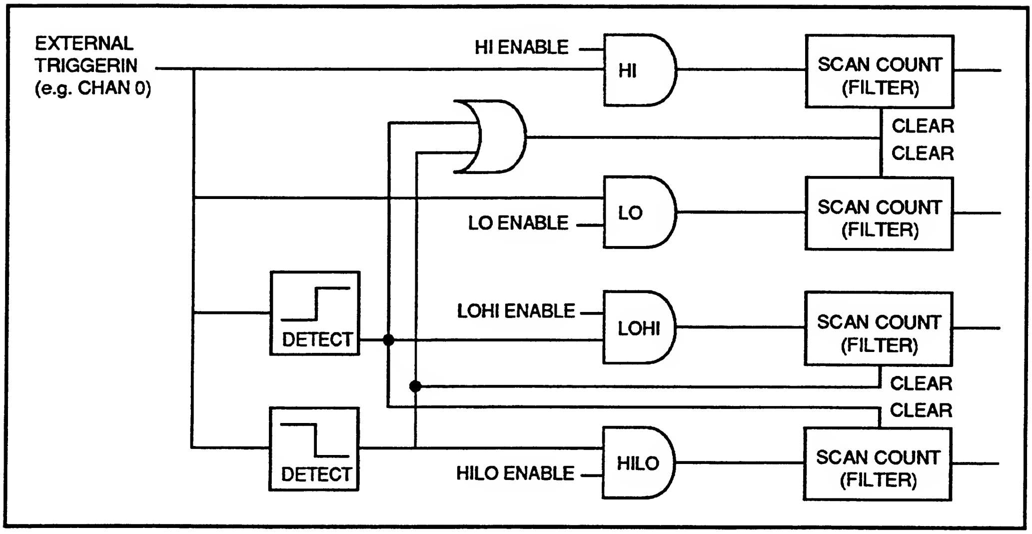


Figure 4-2. External Triggering

ACCESSING RECORDS

Much of the power of Burst Scan Mode is derived from the ability to capture data both before and after the trigger. Therefore, once you have captured data in the buffer, you need to know how to access that data. First, use a a SEND SCANUM command to find out how many scan records there are before the trigger and how many after the trigger. Once you have decided which scan records are of most interest, you can use a SEND BSCAN command to access only the records of interest.

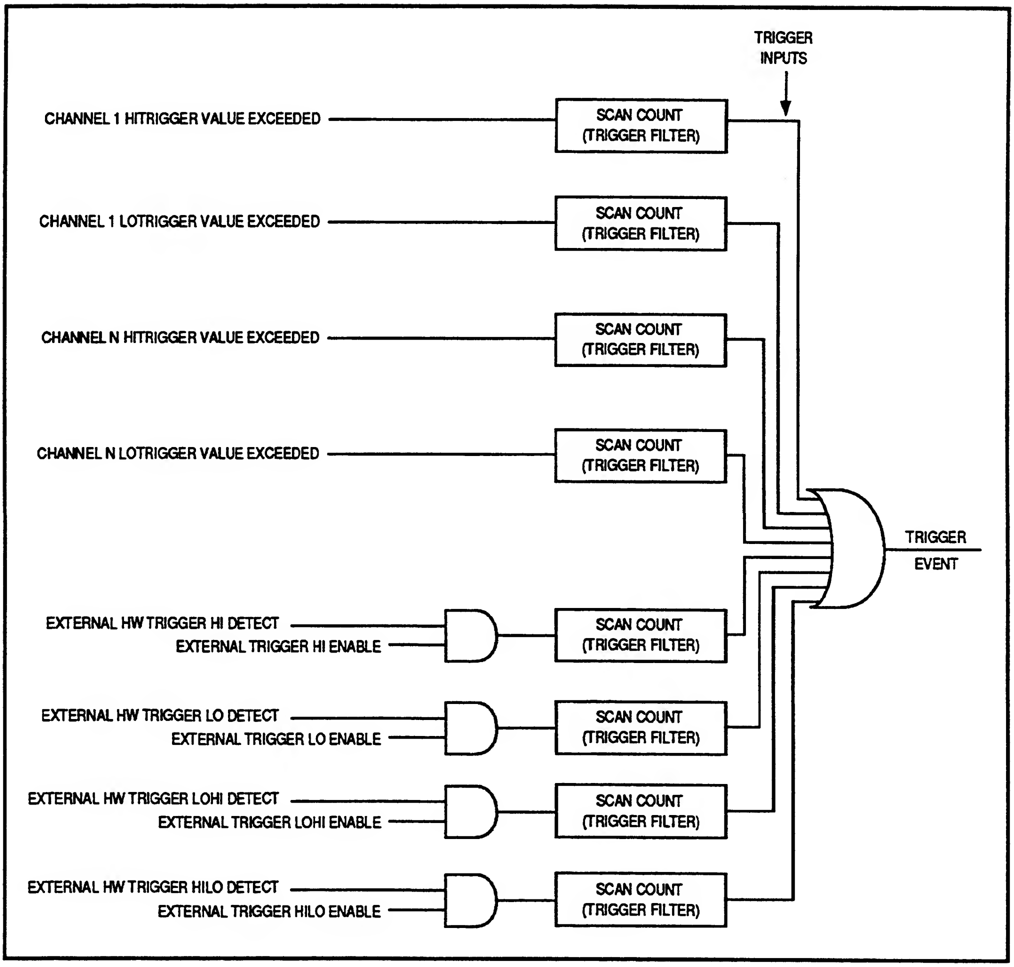


Figure 4-3. Triggering

If you need to capture a transient that requires the use of more than one Fast A/D Converter to achieve the necessary reading rate or the necessary number of channels, this is accomplished by wiring all their External Trigger inputs and outputs together and using a HILO transition trigger. The External trigger inputs are all pulled up normally, so anything that can pull them down causes a trigger event. The external trigger outputs are open-collector NPN transistors, which pull the node down as soon as one of the a/d converters encounters a trigger event.

Channel value triggers on an a/d converter can be used to cause external trigger outputs to trigger other a/d converters. Note that each a/d converter tests its external trigger input only at the end of its own scan. Since scan intervals and other timing considerations may vary between a/d converters, generation of a trigger output by one a/d converter may not be detected until after the completion of a subsequent scan by one or more of the other a/d converters. Thus, a one-scan delay may be experienced.

Table 4-1 shows the scan buffer for various triggering scenarios. In each of the four examples in Table 4-1, the assumed value retrieved by SCANSIZ is 500 and scan record numbering (n) uses the following conventions:

Scan Record 0:	The scan record containing the trigger event.
Scan Record -n:	Scan records acquired prior to the trigger event.
Scan Record +n:	Scan records acquired after the trigger event.

Table 4-1. Burst Scan Buffer

A: TRIGPOS = 0. The burst scan buffer contains only the trigger event and data recorded prior to the trigger event.

n = (SCANSIZ - 1 - TRIGPOS)

SEND SCANUM would retrieve a negative number, followed by 0. This response can range from -1,0 (meaning that the buffer contains only one record occurring before the trigger event record) to -499,0 (signifying that the buffer size of 500 is filled.)

Scan Record 0	(newest record)	**TRIGGER EVENT**
Scan Record -1		
Scan Record -2		
Scan Record -3		
.		
.		
.		
Scan Record -n	(oldest record)	

Table 4-1. Burst Scan Buffer (cont)

B: TRIGPOS = SCANSIZ. The burst scan buffer contains only the trigger event and scan records occurring immediately after the trigger event.

n = (SCANSIZ - 1 - TRIGPOS) = -1

For example, SEND SCANUM retrieves 0,499.

Scan Record TRIGPOS (newest record)

Scan Record (TRIGPOS -1)

Scan Record (TRIGPOS -2)

Scan Record (TRIGPOS -3)

.
.
.

Scan Record 2

Scan Record 1 (first Scan Record after Trigger Event)

TRIGGER EVENT

Table 4-1. Burst Scan Buffer (cont)

C: 0 < TRIGPOS < SCANSIZ.	The burst scan buffer contains the trigger event and data recorded both before and after the trigger event. n = (SCANSIZ - 1 - TRIGPOS) For example, with TRIGPOS = 200, SEND SCANUM retrieves -299,200.

Scan Record TRIGPOS	(newest record)
Scan Record (TRIGPOS -1)	
Scan Record (TRIGPOS -2)	
Scan Record (TRIGPOS -3)	
.	
.	
Scan Record 2	
Scan Record 1	
Scan Record 0	**TRIGGER EVENT**
Scan Record -1	
Scan Record -2	
Scan Record -3	
.	
.	
Scan Record -n	(oldest record)

Table 4-1. Burst Scan Buffer (cont)

D: TRIGPOS > SCANSIZ. The burst scan buffer contains only data recorded after the trigger event (not the trigger event itself).

For example, with TRIGPOS set to 779, SEND SCANUM retrieves 280,779, indicating that the trigger event record has been written over by subsequent scan data and that the buffer contains scan records 280 through 779.

```
Scan Record TRIGPOS                         (newest record)

Scan Record TRIGPOS -1

Scan Record TRIGPOS -2

Scan Record TRIGPOS -3

     .
     .
     .

Scan Record (TRIGPOS - (SCANSIZ - 1))  (oldest record)

- - - - - - - -           (end of buffer)
     .
     .
                                          TRIGGER EVENT
```

OPERATING THE FRONT END FROM A TERMINAL

Terminal Mode allows the Front End to be controlled from a terminal or a computer behaving as a terminal. In this mode the Front End echoes each character it receives (except control characters <CTRL>/S, <CTRL>/Q, <CTRL>/C, DLE, EOT, or ENQ). All prompts and responses to commands from the Front End are displayed in a readable format.

Terminal Mode can be used to verify Front End installation or for familiarization with commands and responses.

Powering Up and Entering Terminal Mode

Terminal Mode is selected by executing the command:

MODE = TERM <CR>

The Front End responds to the command by returning the prompt:

HCLI>

This indicates that the Front End has completed the execution of the command and is ready to receive the next command. Characters entered while the Front End is in TERM mode are echoed and displayed on the terminal screen. If COMP mode is in effect, no characters are echoed.

The mode of operation, either Terminal or Computer, is remembered by the instrument while power is off.

Command Responses

The Front End sends a response back to the terminal for each command executed. The response may simply be the command prompt

HCLI>

or, it could consist of information requested using a SEND or LIST command followed by the command prompt

<send or list data><eol>
HCLI>

or, it could be a descriptive error message followed by the prompt

?<textual error message><eol>
HCLI>

Note that <CR> means a single carriage return character or a carriage return - line feed sequence and <eol> means the end-of-line sequence (EOL system variable).

Specific examples of Front End command responses in Terminal Mode are:

Command: SED CHAN(900)<CR>

Response: ?No such command<eol>
HCLI>

An error has occurred. In this example, the SEND command has been improperly entered.

```
Command:        SEND CHAN(900, 3..4)<CR>

Response:        7.16724E+01<eol>
                -1.23456E-03<eol>
                 0.00000E+00<eol>
                HCLI>
```

Successful measurements were made on channels 900, 3, and 4, and the readings were returned.

```
Command:        LIST CHAN(20)<CR>

Response:       aichan(20)=rtd, type=din385,range=hi<eol>
                HCLI>
```

The response to the LIST CHAN command indicates that channel 20 is defined as an RTD channel.

OPERATING THE FRONT END FROM A COMPUTER

Computer mode is used when the Front End is being operated through a program running on a host computer. Commands from the computer to the Front End are identical to those used in Terminal Mode. Characters are not echoed back to the host computer, however. Responses to commands contain the same information as Terminal Mode responses but the representation is abbreviated to improve throughput and make it easier to interpret with a computer program.

Powering Up and Entering Computer Mode

Computer Mode is set when the Front End is initially powered up or when a RESET ALL command is executed. At any other time, Computer Mode can be selected by executing the command:

```
MODE = COMP <CR>
```

The Front End responds to the command by returning the prompt:

!<eol>

This indicates that the Front End has completed the execution of the command and is ready to receive the next command.

The mode of operation, either Terminal or Computer, is remembered by the instrument while power is off. This warrants a word of caution. If the Front End is in Terminal Mode when powered up it responds to the MODE = COMP <CR> command in terminal mode, that is, echoing the characters back to the host. This means that the MODE = COMP <CR> command response is:

MODE = COMP <CR>
!<eol>

To handle this situation, you can read characters back until the sequence !<eol> is detected. This allows you to get the Front End into computer mode regardless of its mode at power up.

Command Responses

The responses to commands when the Front End is in Computer Mode contain the same information as responses in Terminal Mode. The format of the information is different such that it can more easily be interpreted by a computer program. The response may simply be the command prompt

!<eol>

or, it could consist of information requested using a SEND or LIST command

<send or list data><eol>

or, it could be an error indication in numeric format

?<error number><eol>

Note that <CR> means a single carriage return character or a carriage return - line feed sequence and <eol> means the end-of-line sequence (EOL system variable).

Examples of Computer Mode command responses are:

Command: SED CHAN(900)<CR>

Response: ?27<eol>

An error has occurred. In this example, the SEND CHAN command has been improperly entered.

Command: SEND CHAN(900, 3..4)<CR>

Response:
```
 3.00000E+00<eol>
 7.16724E+01<eol>
-1.23456E-03<eol>
 0.00000E+00<eol>
```

Successful measurements were made on three channels (900, 3, and 4). But note that there are four lines in the response. The first line represents the number of actual measurements, which are found on lines two through four, and is present whenever the COUNT variable is set to ON.

Command: LIST CHAN(20)<CR>

Response:
```
1<eol>
20,1,2,2,0,0<eol>
```

The response to the LIST CHAN command indicates that channel 20 is defined as an RTD channel. Section 5, Command Reference, contains the information necessary to interpret the response to the LIST command.

Implementing a Reliable Communication Link

The previous paragraphs have demonstrated the command set of the Front End. This introduction, and the reference material in Section 5, can be used to compose the necessary commands and read back the responses for a wide variety of applications.

When a computer is using an RS-232 or RS-422 serial link, problems may occur in communicating with a peripheral device (e.g., a Front End). The following paragraphs address these problems.

Serial communication with a peripheral can be remarkably easy. The computer sends out a string of characters (a command) and reads back a string of characters (the response). This could be done with the following BASIC program fragment:

```
10  PRINT #1, "SEND CHAN (9)"
20  INPUT #1, A
```

Line 10 outputs the SEND CHAN (9) command and line 20 reads the response into the variable named A. But what can go wrong? Will this program always work? Consider the following:

- The command sent from the computer may not arrive at the peripheral as it was sent from the computer.

- Characters may be received by the peripheral that were not sent from the computer due to noise in the communication link from wiring, modems, or telephone switching equipment.

- The command response may not be received by the computer in the same format as it was sent from the peripheral.

- o Characters may be received by the computer that were not sent from the peripheral due to noise in the communication link from wiring, modems, or telephone switching equipment.

- o The transmission errors in either direction may not be permanent. They may be intermittent.

The likelihood of having one or more of these problems is dependent on the configuration of your installation. A direct wire configuration where the computer and the Front End are connected together using a shielded null modem cable and located in the same rack of equipment or same room exhibits a very low error rate. However, an installation using modems over a public switched telephone facility could have a modest to frequent error rate. In either case, the following suggestions may help when designing the computer program that sends commands to and reads responses from the Front End.

COMMUNICATION CHARACTER BUFFERING

Serial communications between computers and peripherals often involve the buffering of characters. Buffering is a means to improve the overall system throughput and to manage the disparity between the speed at which the characters can be transmitted and the rate at which they can be processed.

When the computer sends a command to the Front End, the characters go through a buffer residing in the computer before they are transmitted on the RS-232 link. The computer program can put the characters in the buffer extremely fast and, once the characters are buffered, continue executing additional program steps. Characters, meanwhile, are extracted from the buffer at a rate dependent on the baud rate of the link and transmitted out the serial link. The characters are received by the Front End, entered into a buffer and extracted one by one by a program executing on the microcomputer residing within the Front End.

Characters are entered into the Front End's output buffer as a result of executing the received command and then transmitted back to the computer. Now, back at the computer, received characters are buffered and read from the buffer using the programming language's INPUT (or equivalent) statement. All this is taking place behind the scenes to improve system throughput and make the job of writing a program to operate the Front End easy.

Now, the word of caution. If you are not careful, characters could be present in the computer's input buffer that are remnants from earlier commands or spontaneously generated characters resulting from communication link problems. It's a good idea to eliminate the characters in the computer's input buffer and the Front End's output buffer before each command is executed. This helps in assuring that the computer is reading the response to the command and not some garbage characters.

The Front End's input and output buffers can be emptied by issuing the <CTRL>/C command, that is, sending it a single <CTRL>/C (decimal code 3) character.

Also, the host computer programming language usually has some way to clear the input buffers. Often the OPEN statement empties the input buffer. Or, if there is a function that reports the number of characters in the buffer, a simple FOR..NEXT loop can be used to read characters (and throw them away) until the buffer is empty.

TIMEOUTS

A character sent by a computer to a peripheral device may never arrive at the peripheral. This can be caused by an intermittent cabling connection or by any number of noise sources affecting the communication link. When a character of a Front End command doesn't arrive at the Front End, the failure is dependent on which character or characters are lost. If the command termination character is lost, the Front End continues to look fruitlessly for one, and the computer does not receive the command response that it expected.

Characters can also be lost in transit from the peripheral to the computer. This can result in improperly formatted data or insufficient data.

These problems can be taken care of by using a timeout on character reception from the Front End. Anytime the computer expects the Front End to send a character, it should look for that character for a finite time. If no character is received before the timer expires, the system should be reinitialized and the command retried.

The implementation of this scheme in the system depends on the programming language and computer in the system. Many computers and programming languages provide timeouts on formatted input statements. In these situations, a timer is started at the beginning of the execution of an INPUT (or equivalent) statement. If the timer expires before the INPUT statement completes execution, an error routine is called.

Other computers provide more primitive capabilities that allow the timeout to be implemented. They allow the program to obtain the current number of characters in the communications port input buffer, read characters one at a time, and read the system time. These together can be used to implement the timeout scheme.

ERROR BUFFERS

The Front End is designed to accumulate measurement error information detected during SEND command execution. Errors such as "open thermocouple", "over range", "illegal BCD digit", "no convergence", and "over temperature" can be detected and reported back to the computer using a LIST command. The Front End can accumulate and store information on up to twenty errors. If more than twenty errors are detected before being sent back to the computer, the additional error information is lost.

If it is likely that you will encounter these types of errors, it is a good practice to limit the number of channels requested in a SEND command to twenty. Therefore, potentially important error information will not be lost. The computer program should also be designed to read the error information, using the LIST ERROR <CR> command, after each SEND command. This technique prevents multiple SEND commands from overrunning the error buffer.

CONCLUSION

This section has provided an overall view of communications between the computer or terminal and the Front End. It has introduced various command lines that can be sent to the Front End.

This manual now offers several directions. If you are comfortable with Terminal and Computer Mode operations, go ahead and setup the Front End. If you need additional instruction about specific measurements or outputs, refer to Section 6, Measurement Reference. And if you want more specific information about individual commands and the responses to the commands, consult Section 5, Command Reference.